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The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C.-20460

Subject: SAB Review of Emissions Estimating Methodologies for Broiler Animal Feeding Operations and for Lagoons and Basins at Swine and Dairy Animal Feeding Operations

Dear Administrator Jackson:

This Science Advisory Board (SAB) report responds to a request from EPA’s Office of Air and Radiation (OAR) to review and provide advice on scientific issues associated with EPA’s development of Emissions-Estimating Methodologies (EEMs) at two types of animal feeding operations (AFOs): EEMs for barns or buildings at confined broiler AFO facilities, and an EEM for open lagoons and basins at swine and dairy AFO facilities. EEMs are tools for estimating air pollutant emissions from industries where site-specific emissions data are not available.

EPA developed the EEMs for broiler confinement facilities and for open lagoons and basins at swine and dairy AFOs in order to address requirements of a voluntary air compliance consent agreement signed in 2005 between EPA and nearly 14,000 broiler, dairy, egg layer, and swine AFOs. The EEMs will be used by the AFO industry to estimate daily and annual emissions for use in determining their regulatory responsibilities under the Clean Air Act (CAA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Emergency Planning and Community Right-to-Know Act (EPCRA). The pollutants monitored under the agreement include: ammonia, hydrogen sulfide, particulate matter, and volatile organic compounds. As part of the agreement, EPA is charged with developing EEMs for broiler, dairy, egg layer, and swine AFO sectors. EPA developed the broiler and lagoon EEMs after reviewing data on emissions from two key sources: a) the National Air Emissions Monitoring Study (NAEMS), and b) data that EPA received in response to a Call for Information that EPA released seeking additional data on AFOs and emissions to ensure the agency is reviewing the broadest range of available scientific data. The NAEMS is a two-year study of emissions from AFOs that produce pigs, broiler chickens, eggs, and milk. The study was funded by the AFO industry as part of the 2005 voluntary air compliance agreement with EPA.

EPA’s draft EEMs are described in two draft February 2012 documents: “Development of Emissions-Estimating Methodologies for Broiler Animal Feeding Operations” (Broiler Report), and “Development of Emissions-Estimating Methodologies for Lagoons and Basins at Swine and Dairy Animal Feeding Operations” (Lagoon Report). The documents describe the sites monitored and the data submitted to EPA, and provide a detailed discussion of the statistical methodology used to develop the draft EEMs that are to be applied to AFOs throughout the country. The statistical analyses evaluated process parameters to determine if they were predictor variables that EPA could use to develop the EEMs.

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1 EPA's broiler EEMs were developed for ammonia, hydrogen sulfide, particulate matter, and volatile
2 organic compounds using NAEMS emissions and process information collected from ~~four~~two houses on
3 one broiler operation in California and from two broiler operations in Kentucky. EPA's swine and dairy
4 lagoon EEMs for ammonia were developed by combining NAEMS emissions and process information
5 collected from three dairies, three swine breeding and gestation farms, and three swine growing and
6 finishing farms. EPA's statistical analyses ~~resulted in the use of~~used the following input parameters for
7 developing EPA's broiler EEMs: bird inventory; ambient meteorological parameters (i.e., temperature,
8 relative humidity, and barometric pressure), and confinement parameters (i.e., house temperature and
9 relative humidity). ~~EPA's statistical analyses resulted in the use of~~used the following input parameters
10 for developing EPA's swine and dairy lagoon EEM for ammonia: ambient temperature, relative
11 humidity, solar radiation and wind speed.

12
13 The SAB finds that the three broiler facilities and nine swine and dairy facilities used to develop EEMs
14 represent a very small fraction of the one-half million AFOs in the country. The EEMs developed from
15 these limited data are intended to be applied to AFOs throughout the country. The methods used in
16 developing the EEMs are not well suited for extrapolation to conditions beyond those represented in the
17 data set and therefore the EEMs cannot be assumed to be accurate predictors of emissions from other
18 farms in the U.S. SAB concludes that EPA should not apply the current versions of the statistical and
19 modeling tools for estimating emissions beyond those covered in the data set. ~~EPA should consider~~
20 using data collected through mechanisms outside of the consent agreement, including data published in
21 literature, to expand the data set. In addition, SAB does not support the combination of swine and dairy
22 lagoon/basin datasets to develop swine and dairy ammonia ~~and hydrogen sulfide~~ EEMs and finds
23 significant problems with EPA's approach of using static predictor variables as surrogates for data on
24 dynamic lagoon/basin conditions. In addition, SAB finds that there are significant uncertainties
25 associated with the broiler volatile organic compounds data used in EPA's analysis and concludes that
26 these data are insufficient to support development of a broiler EEM for volatile organic compounds at
27 this time.

28
29 The SAB also finds that the EPA's EEMs in both Reports are based on statistical analyses of datasets
30 that ~~resulted in development of a small number of input parameters and that~~ use mathematical models on
31 key variables (e.g., cubic model with bird weight) that cannot be ~~confidently~~ extrapolated beyond the
32 range of values in the data set. In their current form, these EEMs and statistical interpretations cannot be
33 assumed to represent other farms in the U.S. The EEMs and associated Reports should be revised to
34 improve the ~~statistical~~ analyses of the datasets and more appropriately reflect processes at AFO sectors.

35
36 SAB strongly recommends that EPA develop a process-based modeling approach to make predictions of
37 air emissions on broiler confinement houses and swine and dairy lagoons/basins. A process-based
38 model would quantify the flows of materials from one process on a farm to the next (e.g., flows from
39 feed through the animal housing to manure storage to field application and crop production). Process-
40 based models would require consideration of emissions from each component of the farm system based
41 on the concentrations and amount of reactants that lead to the emission from that component. By
42 representing chemical and physical processes and constraints in an EEM, the SAB concludes that
43 process-based models are more likely than the current statistical models to be successful in representing
44 a broad range of conditions. This recommendation is directly supportive of recommendations provided
45 to EPA in the 2003 National Research Council report *Air Emissions from Animal Feeding Operations:
46 Current Knowledge, Future Needs*. In their most rigorous forms, EEMs are data intensive; however,

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1 process considerations can be incorporated into models at a variety of levels of complexity. EPA should
2 consider developing EEMs at a variety of levels of complexity to provide options for producers with
3 different levels of data availability. While the NAEMS does not provide sufficient data to implement a
4 rigorous process-based modeling approach, it is sufficient to start the development of a full model. EPA
5 should identify critical data gaps and begin the process of identifying key parameters to ~~be~~
6 ~~included~~include within the process-based models.–EPA should also consider conducting a full mass
7 balance analysis to help in the assessment of key parameters that would be used in a process-based
8 modeling approach. Within the body of this report, SAB has identified several key factors and
9 parameters that affect emissions that EPA should consider within process-based modeling approaches
10 and recommends several alternative approaches for developing a draft process-based lagoon/basin EEM
11 for ammonia emission. SAB also has several recommendations regarding EPA’s handling of negative
12 and zero values for both direct concentration measurement and calculated emission values.

13
14 The SAB appreciates the opportunity to provide EPA with advice on this important subject. We look
15 forward to receiving the Agency’s response and to providing future advice on this topic.

16
17
18 Enclosures

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This report has been written as part of the activities of the EPA Science Advisory Board, a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide balanced, expert assessment of scientific matters related to the problems facing the agency. This report has not been reviewed for approval by the agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute a recommendation for use. Reports of the EPA Science Advisory Board are posted on the EPA website at <http://www.epa.gov/sab>.

Suggested Changes to 9/28/12 Draft Report, for review and deliberations by the SAB Animal Feeding Operations Emissions Panel during the 10/24/12 teleconference call –

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33 | **Science Advisory Board**
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39 | **Animal Feeding Operations Emission Review Panel**
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ACRONYMS AND ABBREVIATIONS

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3	AFOs	Animal Feeding Operations
4	AFO Panel	SAB Animal Feeding Operations Emissions Review Panel
5	bLS-	Backward Lagrangian Stochastic Model
6	CAA	Clean Air Act
7	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
8	CH ₄ -	Methane
9	EEMs	Emissions-Estimating Methodologies
10	EPA	U.S. Environmental Protection Agency
11	EPCRA	Emergency Planning and Community Right-to-Know Act
12	ER	Emission Rate
13	H ₂ S	Hydrogen Sulfide
14	MDL	Minimum Detection Level
15	NAEMS	National Air Emissions Monitoring Study
16	N	Nitrogen
17	NH ₃	Ammonia
18	NH ₄	Ammonium
19	OAR	Office of Air and Radiation
20	PM	Particulate Matter
21	QA/QC	Quality Assurance/Quality Control
22	RPM	Radial Plume Mapping
23	S	Sulfur
24	SAB	EPA Science Advisory Board
25	SPV	Static Predictor Variables
26	THM	Trihalomethanes
27	TSP	Total Suspended Particulates
28	VOCs	Volatile Organic Compounds
29	VR	Ventilation Rate
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1. EXECUTIVE SUMMARY

EPA's Office of Air and Radiation (OAR) requested the Science Advisory Board (SAB) to review two draft documents related to animal feeding operations (AFOs) emissions ("Development of Emissions-Estimating Methodologies for Broiler Animal Feeding Operations" and "Development of Emissions-Estimating Methodologies for Lagoons and Basins at Swine and Dairy Animal Feeding Operations"). In these documents, EPA described draft emissions-estimating methodologies (EEMs) for broiler ~~animal feeding operations~~AFOs and for lagoons and basins at swine and dairy AFOs in order to address requirements of a voluntary air compliance consent agreement signed in 2005 between EPA and nearly 14,000 broiler, dairy, egg layer, and swine AFOs. EPA requested the SAB to provide advice on scientific issues associated with EPA's development of the EEMs. The SAB was asked to comment on various aspects of EPA's draft Reports, including EPA's overall approach for developing the EEMs, combination of Lagoon and Basin data, use of static predictor variables within the EEMs, specific approaches for development of the ~~Ammonia~~ammonia (lagoon NH₃)-and broiler volatile organic ~~compounds~~(VOCs)compound (VOC) EEMs, and handling negative and zero data results.

The SAB Animal Feeding Operations Air Emissions Review Panel (AFO Panel) reviewed the draft EPA documents, considered public comments that were received on the draft Reports, and held a public meeting on March 14, 15 and 16, 2012 to provide advice to EPA on the scientific adequacy, suitability and appropriateness of EPA's EEMs and draft Reports. At the March 2012 public meeting, the SAB Panel considered oral statements that were received from the public and raised several questions and requested additional data which EPA responded to in separate documents that EPA submitted to the Panel in July and August 2012. The SAB held a follow-up public teleconference call on August 13, 2012 to review EPA's responses and the additional data and consider whether EPA's supplemental responses changed any of the Panel's preliminary key issues and recommendations that were raised at the March 2012 SAB Panel meeting. The AFO Panel held a public teleconference on October 24, 2012, to discuss substantive comments from Panel members on the draft SAB report "SAB Review of Emissions Estimating Methodologies for Broiler Animal Feeding Operations and for Lagoons and Basins at Swine and Dairy Animal Feeding Operations:". The enclosed report provides the advice and recommendations of the SAB through the efforts of the SAB Animal Feeding Operations Emissions Review Panel.

In its review of the EEMs-, the SAB finds that a small number of broiler, swine and dairy facilities were used to develop the EEMs, and the EEMs developed from this limited sample are intended to be applied to AFOs throughout the country. The methods used in developing the EEMs are not well suited for extrapolation to conditions beyond those represented in the data set and therefore the EEMs cannot be assumed to be accurate predictors of emissions from other farms in the U.S. SAB concludes that EPA should not apply the current versions of the models for estimating emissions beyond those covered in the data set.

As outlined in responses to specific charge questions below, the EPA should consider using data collected through mechanisms outside of the consent agreement, including data published in literature, to expand the data set-. The SAB does not support the combination of swine and dairy datasets to develop the swine and dairy lagoon/basin ammonia ~~and hydrogen sulfide~~-EEM since the differences in

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1 nutrient concentration and manure composition between swine and dairy lagoons and dairy basins make
2 it erroneous to combine the data from these sources. The SAB finds significant ~~restrictions~~
3 ~~with limitations inherent in~~ EPA's approach of using static predictor variables as surrogates for data on
4 dynamic lagoon/basin conditions because such an approach would obscure key emission processes and
5 variable interactions and fail to account for regional and inter-species variability among the fundamental
6 drivers of emission processes. In addition, SAB finds that there are significant uncertainties associated
7 with the broiler ~~VOC/VOC~~ data used in EPA's analysis, and concludes that these data are
8 insufficient to support development of a broiler ~~EEMs/EEM~~ for VOCs at this time.
9

10 SAB strongly recommends that EPA ~~develop~~use a process-based modeling approach to make
11 predictions of air emissions from broiler confinement houses and swine and dairy lagoons/basins. This
12 recommendation is directly supportive of recommendations provided to EPA in the 2003 National
13 Research Council report *Air Emissions from Animal Feeding Operations: Current Knowledge, Future*
14 *Needs*.
15

16 A process-based model would quantify the flows of materials from one process on a farm to the next
17 (e.g., process flows from feed through the animal housing to manure ~~storage to field application and~~
18 ~~crop production~~). Process-based models would require consideration of emissions from each
19 component of the farm system based on the concentrations and amount of reactants that lead to the
20 emissions from that component. ~~In process-based emission modeling, system processes are~~
21 ~~mathematically represented at an appropriate level of detail to capture the important dynamics and~~
22 ~~interactions among components. In the most rigorous form, a process-based model is developed from~~
23 ~~the scientific understanding of the physical, biological, and other processes that control emissions.~~
24 ~~Although empirical data may be used to help establish certain model parameters or relationships, the~~
25 ~~primary need for empirical data is for evaluation or verification of the mechanistic models used to~~
26 ~~describe system processes. This is different from an empirical approach where regression techniques are~~
27 ~~used to formulate models from experimental data and independent datasets are needed for validation.~~
28 ~~Process-based modeling provides a robust emission estimation approach, since the mechanistic models~~
29 ~~are expected to be valid beyond the datasets used to establish model parameters.~~
30

31 By representing the chemical and physical processes and constraints in an EEM, the SAB concludes that
32 process-based models are more likely than the current statistical models to be successful in representing
33 a broad range of conditions. In their most rigorous forms, ~~EEMs/process-based models~~ are data
34 intensive; however, process considerations can be incorporated into models at a variety of levels of
35 complexity. EPA should consider developing EEMs at a variety of levels of complexity to provide
36 options for producers with different levels of data availability. While the NAEMS does not provide
37 sufficient data to implement a rigorous process-based modeling approach, it is sufficient to start the
38 development of a full model. ~~SAB also encourages EPA to estimate uncertainty associated with~~
39 ~~predictions from the model.~~
40

41
42
43 In addition, SAB recommends that after EPA updates its approaches for developing EEMS for broiler
44 confinement houses and swine and dairy lagoons/basins consistent with SAB's advice, EPA use these
45 updated approaches to develop draft EEMs for egg-layers, swine and dairy confinement houses. Thus,
46 assuming these sectors have similar data limitations issues as are evident for the broiler confinement

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1 houses and swine and dairy lagoons/basins sectors, EPA should not plan to apply statistical and
2 modeling tools that EPA would develop for estimating emissions beyond those of the dataset. SAB also
3 recommends that EPA should develop a process-based modeling approach to make predictions of air
4 emissions on these sectors.

5
6 SAB recognizes that there are potential drawbacks with developing and applying process-based models
7 to assess emissions at AFO facilities. National consistency in assessing emissions using such a tool may
8 be difficult to achieve. Since a process-based model may not be appropriately applied for all farms
9 across the nation in a particular AFO sector, a large number of parameters and static variables may be
10 required to address the variety of factors that affect emissions on a number of farms within a sector.
11 Also, interactions between the parameters may need to be assessed and incorporated into the modeling
12 approach. Separate decisions would likely be required on which parameters and static variables should
13 be incorporated into the process-based model that would be applied for each farm, resulting in different
14 applications of a processed-based modeling approach for each farm.

15
16 A more detailed description of the technical recommendations is included in this SAB Report, and the
17 responses to specific charge questions are highlighted below.

18 19 **Charge Question 1: EPA'S Approach for Developing the EEMS**

20
21 *Please comment on the statistical approach used by the EPA for developing the draft EEMS for broiler*
22 *confinement houses and swine and dairy lagoons/basins. In addition please comment on the approach*
23 *for developing draft EEMS for egg-layers, swine and dairy confinement houses.*

24
25 EPA developed separate broiler ~~confined source~~confinement house EEMs for NH₃, PM₁₀, PM_{2.5}, TSP,
26 ~~VOE~~VOCs, and H₂S using emissions and process information collected from one broiler operation in
27 California and from two broiler operations in Kentucky. EPA developed a swine and dairy lagoon open
28 source EEM for NH₃ using emissions and process information collected from three dairies, three
29 breeding and gestation swine farms, and three swine growing and finishing farms. EPA used the
30 Statistical Analysis Software (SAS) package to statistically evaluate ~~process~~ parameters to determine if
31 the predictor variables- could be used by the EPA to develop these EEMs. Based on the results of
32 EPA's predictor analysis, broiler EEMs were developed using the following input parameters: bird
33 inventory; ambient meteorological parameters (i.e., temperature, relative humidity, and barometric
34 pressure), and confinement parameters (i.e., house temperature and relative humidity). EPA's swine and
35 dairy lagoon NH₃ EEM was developed using the following input parameters: ambient temperature,
36 relative humidity, solar radiation, and wind speed.

37
38 SAB has a number of suggestions for improving the ~~statistical~~modeling approach used by the EPA for
39 developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins. The
40 EEMs developed from ~~this~~the limited data are intended to be applied to AFOs throughout the country.
41 The SAB finds that the EPA's EEMs in both Reports are based on statistical analyses of datasets that
42 resulted in ~~development~~use of a small number of input parameters and that use mathematical
43 dependencies on key variables (e.g., cubic dependence on bird weight) that cannot be ~~confidently~~
44 extrapolated beyond the range of values in the data set. The ~~approach used in developing the~~data and
45 ~~resulting~~ EEMs are not well suited for extrapolation to conditions beyond those represented in the data

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1 set and therefore the EEMs cannot be assumed to be accurate predictors of emissions from other farms
2 in the U.S.

3
4 SAB concludes that EPA should not apply the current versions of the statistical and modeling tools for
5 estimating emissions beyond those ~~covered in of the data set--dataset~~. EPA should consider using data
6 collected through mechanisms outside of the consent agreement, including data published in literature,
7 ~~raw data from key studies, and data that support key literature.~~ Suggestions for literature that should be
8 considered are included within the attached References. ~~EPA should consider the effects of location~~
9 ~~(site or farm), house within location, and flocks within house in model inference and prediction.~~ EPA's
10 model uncertainty analysis should recognize the limitations in using a small number of locations. EPA
11 should consider approaches in addition to the cross-validation method used to evaluate the ~~model~~EEMs.

12
13 In addition, SAB is concerned that EPA's application of polynomial regression for nonlinear models
14 (e.g., the use of cubic functions to represent nonlinear dependence in average mass of animals) leads to
15 poor predictions near the extremes of the experimental conditions and when the models are extrapolated
16 outside of the range encountered in the data set (as would be likely in application of the EEMs to AFOs
17 nationwide). SAB suggests that EPA restrict the range of mass that should be reported if the cubic
18 model is used. SAB also recommends that orthogonal polynomials should be used if a polynomial
19 approach is taken. EPA should also provide more information on the merits of applying such regression
20 analysis within this project.

21
22 SAB also strongly recommends that EPA should develop a process-based modeling approach to make
23 predictions of air emissions on broiler confinement houses and swine and dairy lagoons/basins. A
24 process-based model would quantify the flows of materials from one process on a farm to the next (e.g.,
25 flows from feed through the animal housing to manure ~~storage to field application and crop production~~).
26 ~~Process-based models would require consideration of emissions from each component of the farm~~
27 ~~system based on the concentrations and amount of reactants that lead to the emission from that~~
28 ~~component~~). By representing the chemical and physical processes in an EEM, the SAB concludes that
29 process--based models are more likely than the current ~~statistical~~ models to be successful in
30 representing a broad range of conditions. ~~In their most rigorous forms, EEMs are data intensive,~~
31 ~~however, process considerations can be incorporated into models at a variety of levels of complexity.~~
32 EPA should consider developing EEMs at a variety of levels of complexity to provide options for
33 producers with different levels of data availability. --A simple approach might use a small number of
34 variables to place constraints on predicted emissions, such as limiting total predicted ammonia emissions
35 based on the nitrogen available in feed. A more complex approach to the same emissions might attempt
36 to perform a mass balance on nitrogen. EPA should also identify critical data gaps associated with
37 development of such modeling approaches and begin the process for identifying which key parameters
38 should be included within the process-based models. EPA should consider conducting a full mass
39 balance analysis to help in the assessment of key parameters that would be used in a process-based
40 modeling approach.

41
42 SAB has identified several key factors and parameters that EPA should consider within process-based
43 modeling approaches. Key factors and parameters that impact broiler emissions may include animal
44 activity (perhaps assessed through lighting program hours for light and dark periods), ~~diets, feed rate and~~
45 ~~composition~~, key diet ingredients (that result in releases of gaseous pollutants, such as total nitrogen),

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1 | water management, manure composition (moisture and nitrogen), ~~feed composition including total~~
2 | ~~nitrogen that result in releases of gaseous pollutants~~, total number of ~~animals~~ animal units, and
3 | ventilation rate. Key factors and parameters that affect dairy and swine lagoon emissions may include
4 | sulfur, nitrogen and carbon content of feed, conversion of feed nutrients to animal product (milk and
5 | meat) ~~as a percentage of excreted manure collected in liquid~~ storage, nutrients fed, milk production
6 | levels and composition for dairies, seasonality, and the lagoon sulfur, nitrogen and carbon content,
7 | surface area, depth, manure residence time, volume, temperature and pH ~~of the lagoons~~. The National
8 | Air Emissions Monitoring Study (NAEMS) does not provide sufficient data to ~~produce~~ evaluate and
9 | estimate parameters for a full model incorporating all of these key factors and parameters ~~but is~~
10 | ~~sufficient to start the development of a suite of models of varying complexity~~. In particular, the
11 | NAEMS data set did not include sufficient information for the steps from feed development to manure
12 | collection. Also, the NAEMS swine and dairy lagoons/basins data are particularly limited regarding
13 | feed input data, nutrient and chemical loading inputs into lagoons, and the chemical and physical
14 | composition and pH of lagoons ~~—~~.

15 |
16 | In addition, SAB recommends that after EPA updates its approaches for developing EEMS for broiler
17 | confinement houses and swine and dairy lagoons/basins consistent with SAB's advice, EPA use these
18 | updated approaches to develop draft EEMs for egg-layers, swine and dairy confinement houses. Thus,
19 | assuming these sectors have similar data limitations issues as are evident for the broiler confinement
20 | houses and swine and dairy lagoons/basins sectors, EPA should not plan to apply statistical and
21 | modeling tools that EPA would develop for estimating emissions beyond those of the dataset. EPA
22 | should consider using data collected through mechanisms outside of the consent agreement, including
23 | data published in literature, raw data from key studies, and data that support key literature. SAB also
24 | recommends that EPA should develop a process-based modeling approach to make predictions of air
25 | emissions on these sectors. EPA should consider developing EEMs at a variety of levels of complexity
26 | to provide options for producers with different levels of data availability. EPA should also identify
27 | critical data gaps associated with development of such modeling approaches and begin the process for
28 | identifying which key parameters should be included within the process-based models. EPA should
29 | consider conducting a full mass balance analysis to help in the assessment of key parameters that would
30 | be used in a process-based modeling approach.

31 | 32 | **Charge Question 2: -Combination of Lagoon and Basin Data**

33 |
34 | *Please comment on the agency's decision to combine the swine and dairy dataset to ensure that all*
35 | *seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's*
36 | *comments on whether the agency should combine lagoon and basin data.*
37 |

38 | After conducting an initial analysis of the NAEMS data submitted for swine and dairy lagoons/basins,
39 | EPA began developing a draft EEM for NH₃. EPA's review of the literature indicated that lagoon/basin
40 | emissions were influenced by several factors, including lagoon/basin pH and temperature. To enable the
41 | dataset used to develop the draft EEM to represent all seasonal meteorological conditions for the entire
42 | two-year monitoring period, EPA decided to combine the swine and dairy data to develop the draft NH₃
43 | EEM, and is considering whether to combine the swine and dairy data to develop the draft hydrogen
44 | sulfide EEM.
45 |

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1 | SAB strongly recommends that EPA not combine the swine and dairy ~~dataset~~datasets. The differences
2 | in nutrient concentration and manure composition between swine and dairy lagoons and dairy basins
3 | make it erroneous to combine the data from these sources. Lagoons and basins are not the same and
4 | operate very differently; a lagoon is used to provide biological treatment and long term storage, and a
5 | basin is used for short term storage and may not provide biological treatment. Lagoon decomposition of
6 | manure is much greater than in a basin, since lagoons maintain bacterial populations to aid in the
7 | digestion of newly added manure while basins do not. In addition, characteristics of swine and dairy
8 | manure are significantly different. A combination of these two datasets would overlook the basic
9 | differences in microbial processes and waste characteristics and undermine the credibility of conclusions
10 | drawn from such analyses.

11 |
12 | EPA justifies combining the swine and dairy data to ensure that multiple seasonal meteorological
13 | conditions are represented and a sufficiently large enough data set is available for analysis. Although
14 | this combination of data sets attempts to resolve problems associated with inadequate sample design by
15 | combining data from separate species, ~~it~~EPA should not ~~be done~~combine this data.

16 |
17 | Furthermore, it is not appropriate to combine the data ~~from different lagoons/basins~~ within species if
18 | there ~~is~~are no predictor variables describing the chemical, physical, and biological characteristics of the
19 | lagoons ~~included~~in the model. For example variations in the chemical composition of dairy lagoons
20 | across the country, driven by differences in manure handling systems lead to differences in the processes
21 | that control ammonia (or other compound) emissions. Separating the swine and dairy lagoon data while
22 | still using the predictor variables selected in the current EEMs (i.e., ambient temperature, relative
23 | humidity, solar radiation and wind speed) will only provide an estimate for the specific lagoons ~~that~~
24 | ~~that~~included in the ~~models were based~~dataset.

25 | ~~The~~
26 | EPA should identify key gaps in the lagoon and basin data and ~~should~~consider using data collected
27 | through mechanisms outside of the consent agreement, including ~~data~~those published in literature, ~~data~~
28 | ~~that support key literature, and raw data from key studies,~~ to address data gaps.

29 | 30 | **Charge Question 3: -Use of Static Predictor Variables**

31 |
32 | *Please comment on the agency's decision to use static predictor variables as surrogates for data on*
33 | *lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that EPA*
34 | *consider specific alternative approaches for statistically analyzing the data that would allow for the site-*
35 | *specific lagoon liquid characteristics to be used as predictor variables?*
36 |

37 | To maximize the number of NH₃ emissions measurements used to develop the draft EEM, EPA used
38 | static predictor variables as surrogates for data on lagoon/basin conditions (i.e., nitrogen content of
39 | lagoon liquid, lagoon pH, oxidation reduction potential and temperature). EPA used the static variables
40 | of animal type, total live mass of animal capacity on the farm, and the surface area of the lagoon to
41 | represent total nitrogen loading ~~rates~~ and the potential for release to the air. SAB finds significant
42 | problems with EPA's approach of using static predictor variables as surrogates for data on lagoon/basin
43 | conditions. Such an approach would obscure key emission processes and variable interactions and fail
44 | to account for regional and inter-species variability among the fundamental drivers of emission

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1 processes. It would be inappropriate to extrapolate this approach to operations not represented by the
2 study locations.

3
4 Several of EPA's static predictor variables are also individually deficient. For example, ~~the~~
5 ~~lagoon~~/basin surface area is generally highly variable at swine and dairy facilities, particularly in
6 situations where ~~lagoons~~/basins have sloping sides, where small changes in ~~surface~~ water depth can
7 translate into large changes in surface area. Also, animal numbers represent a fundamental variable that
8 drives nitrogen loading and, subsequently, NH₃ emissions. In addition, the range of climatic,
9 management, feeding, and animal-performance conditions represented by the ~~livestock operations~~ AFOs
10 in the NAEMS ~~study~~ is too narrow to provide reliable emission estimates across the full range of
11 conditions in which dairy and swine producers operate in the ~~United States~~ U.S. (e.g., moderate winters
12 or extended, hot summers are not represented).

13
14 As discussed further under the response under Charge Question 1, SAB recommends that EPA develop a
15 process-based approach that uses appropriate, physically- ~~and chemically~~-based, region- and species-
16 specific variables-. SAB also recommends that the functional relationships in any statistical model
17 should be based on the key drivers of emission processes.

18 19 20 **Charge Question 4: ~~Alternative Approaches for Developing the NH₃ EEM~~**

21
22 *Does the SAB recommend that EPA consider alternative approaches for developing the draft NH₃ EEM*
23 *that balances the competing needs for a large dataset (to reflect seasonal meteorological conditions)*
24 *versus incorporating additional site-specific factors that directly affect lagoon emissions. If so, what*
25 *specific alternative approaches would be appropriate to consider?*

26
27 ~~EPA requested SAB advice on alternative approaches for developing an NH₃ EEM that would balance~~
28 ~~the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus~~
29 ~~incorporating additional site-specific factors that directly affect lagoon emissions.~~ SAB concludes that
30 EPA should consider the following alternative approaches for developing a draft ~~lagoon~~ NH₃ EEM,
31 since there are limited data and the EEM ~~should~~ **needs to** be broadly applicable across the U.S. for
32 determining emissions from lagoons:

- 33
34 • Expand Data Completeness Methodology:- EPA's data completeness methodology assumes that
35 a valid monitoring hour is one in which 75% of the data recorded during that hour were valid-
36 .EPA should expand its data completeness criteria in order to increase the amount of data
37 available to develop an NH₃ EEM. SAB finds that EPA should include data with less than 75%
38 completeness for any given hour, since there are already many gaps in the data used for the
39 development of these EEMs. In addition, EPA should examine the 75% completeness criteria
40 for daily averages (A valid monitoring day is one in which 75% of the hourly average data
41 values used were valid). ~~These data need to be examined to ensure that there are not blocks of~~
42 ~~missing hourly averages that could affect the overall daily averages.~~ EPA should consider
43 whether the missing hourly values are random or whether they occurred in some discernible
44 pattern, and consider using methods to "gap fill" missing data.

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- 1 | • Use bLS Data Instead of RPM Data or ~~In~~ Conjunction ~~With~~with RPM Data: EPA’s calculated
2 | daily lagoon emissions were developed based on measurements obtained using the “Radial
3 | Plume Mapping” (RPM) model rather than the “backward Lagrangian stochastic” (bLS) model.
4 | EPA should consider using the emissions estimated with the bLS method, since there is such a
5 | paucity of data in the current RPM dataset. Since the drivers of emissions (i.e., lagoon chemistry
6 | and biology) are changing slowly (more in terms of weeks or months, not minutes), it may be
7 | preferable to use daily average data values rather than hourly values. If daily values are used, the
8 | bLS dataset has 285 valid days as opposed to only 69 valid days using the RPM model. These
9 | daily averages could be used in conjunction with measured lagoon characteristics in order to
10 | ~~have~~develop a more robust model. In addition, published validation studies indicate that the bLS
11 | model has performed very well for open area sources.
12 |
- 13 | • Revise Units for Emissions Estimates: EPA’s unit for emissions is kg/30-min. SAB finds that
14 | EEMs that use kg/ha or kg/live wt or some other denominator that captures the physical
15 | differences of the operations would more appropriately account for actual emissions that are
16 | released at dairy and swine facilities.
17 |
- 18 | • Use Appropriate Predictor Variables to Estimate Emissions: EPA should apply both the
19 | environmental factors (manure temperature, air temperature, wind speed, and solar radiation) and
20 | predictor factors/variables that actually drive emissions. These variables include available
21 | lagoon chemistry data such as nitrogen content and pH of the lagoon, and the manure
22 | management system. The potential effects of surface crust on ~~reducing~~ emissions should also be
23 | considered. EPA’s predictor factors/variables should have realistic biological thresholds and
24 | boundaries to ensure that the methodology does not result in an estimated emission rate that is
25 | not feasible. SAB also recommends that EPA compare the results of the EEMs that it develops
26 | with emissions reported in the literature.
27 |
28 |
29 |

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1 | **Charge Questions 5 and 6: -Approaches for Handling Negative and Zero Data**

2
3 | *Please comment on the EPA's approach for handling negative or zero emission measurements.*
4 | *In the interest of maximizing the number of available data values for development of the draft H2S*
5 | *EEMs for swine and dairy lagoons/basins, does SAB recommend any alternative approaches for*
6 | *handling negative and zero data other than the approach used by the agency.*
7

8 | Some NAEMS emissions measurements were reported as either negative or zero emissions values. EPA
9 | considered whether to include these negative and zero emissions values in the data used to develop the
10 | EEMs.—EPA evaluated whether the negative or zero values represented variability in emissions
11 | measurements due to instrument/equipment performance and concluded that all negative values should
12 | not be considered in the development of the EEMs. EPA also reviewed the data to see if the data quality
13 | measures were properly performed according to the Quality Assurance Project Plan.
14

15 | SAB has several recommendations regarding EPA's handling of negative and zero values for both direct
16 | concentration measurement and calculated emission values. In general, a zero or negative direct
17 | concentration measurement value can occur due to a true value that is at or below the Minimum
18 | Detection Level (MDL), instrument measurement error, a measurement value that is adjusted by the
19 | equipment calibration offset procedure, and instrument fluctuation due to influence by ambient
20 | conditions. Each of these cases is considered individually and recommendations are provided in the full
21 | report. ~~in~~. In some cases the SAB recommends that zero and negative direct concentration values be
22 | included in the development of EEMs.
23

24 | Negative and zero calculated emission data should be generally included when calculating EEMs. If the
25 | measured concentration data are considered valid and included in the dataset, then the emission value
26 | calculated from that dataset should also be considered valid, whether it is negative, zero or positive. If
27 | the calculated value is negative, EPA should consult the raw data to assess whether the value was due to
28 | calculation, instrument results, ambient conditions, or some other effect.
29

30 | Outliers (observations that appear to be different from the other observations in the sample set) should
31 | be first treated per the quality assurance/quality control process to determine (if possible) their origin
32 | and then included or not in EPA's analyses with a clear explanation ~~and documentation~~ for the decisions
33 | made.
34

35 | **Charge Question 7:- Broiler VOC EEM**

36
37 | *Please comment on the approach EPA used to develop the draft broiler VOC EEM.*
38

39 | EPA reviewed the VOC ~~compounds~~-data submitted for the California and Kentucky broiler sites. The
40 | two sites used different VOC measurement techniques. Based on analysis of the measurement and
41 | analytical techniques and the VOC data, EPA used only the VOC data from the Kentucky sites when
42 | developing the draft VOC EEM.
43

44 | SAB finds that there are significant uncertainties associated with the broiler VOC data collected as part
45 | of the NAEMS ~~study~~. SAB therefore concludes that the broiler VOC data cannot support the

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1 development of a broiler VOC EEM at this time. Although the NAEMS dataset is too limited to
2 produce an EEM, there are valuable components of the VOC data that should be reported. SAB
3 concludes that the KY1B VOC data may generally be valid and usable if EPA extensively and clearly
4 documents the methods that were used to collect VOC data. EPA should also provide information on
5 the total and speciated VOC concentrations at the sites where data were collected. SAB recommends
6 that EPA investigate the factors that drive generation of VOC emissions from broiler facilities and
7 develop a process-based modeling approach to estimate VOC emissions from these operations.
8

9 **General Comments on the Draft Broiler and Lagoon Reports**

10
11 In addition to evaluating the technical content of the reports, SAB considered whether the draft Broiler
12 and Lagoon Reports were presented in a clear, comprehensive, and scientifically sound manner. SAB
13 also identified suggestions for alternative analyses or presentation that should be conducted. Overall,
14 the SAB finds that many areas of EPA's draft documents should be enhanced to strengthen the clarity
15 and scientific basis of EPA's analyses. SAB finds that both Reports should be updated to describe the
16 importance of retaining a long-term goal for producing process-based models and to indicate additional
17 data received by the agency from the NAEMS science advisor since the time of their initial publication.
18 The SAB also concludes that the Reports should more comprehensively describe data completeness,
19 representativeness, and limitations, and whether there are sufficient data to begin a process-based
20 modeling approach. Various suggestions are included for improving EPA's statistical approach.
21 Furthermore, SAB recommends that the Reports more fully explain why any of the NAEMS data were
22 excluded from EEM development. Since NAEMS data have significant limitations, the Reports should
23 include an assessment that considers use of 'outside' data that ~~was~~ were not collected as part of the
24 NAEMS data collection effort.
25
26

2. INTRODUCTION

A2.1. Background

In 2011, EPA’s Office of Air and Radiation (~~OAAOAR~~) initiated the development of draft emissions-estimating methodologies (EEMs) for animal feeding operations (AFOs) at broiler confinement facilities and for open lagoons and basins at swine and dairy AFOs. EEMs are tools for estimating emissions from AFOs and are commonly used to estimate emissions from industries where site-specific emissions data are not available. EPA developed ~~EEMs for Elmsford~~ confinement structures (e.g., barns or buildings at broiler facilities) and for open ~~area~~ sources (~~manure i.e.~~, lagoons and basins at swine and dairy facilities).

EPA developed the EEMs for broiler confinement facilities and for open lagoons and basins at swine and dairy AFOs in order to address requirements of a voluntary air compliance consent agreement signed in 2005 between EPA and nearly 14,000 broiler, dairy, egg layer, and swine ~~animal feeding operations-AFOs~~. The goals of the agreement are to reduce air pollution, monitor AFO emissions, promote a national consensus on methodologies for estimating emissions from AFOs, and ensure compliance with the requirements of the Clean Air Act (CAA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Emergency Planning and Community Right-to-Know Act (EPCRA). The EEMs will be used by the AFO industry to estimate daily and annual emissions for use in determining their responsibilities under these regulatory programs. The pollutants monitored under the agreement include: ammonia, hydrogen sulfide, particulate matter, and VOCs. As part of the agreement, EPA is charged with developing EEMs for broiler, dairy, egg layer, and swine AFO sectors.

At broiler confinement facilities, young chickens between 28 to 63+ days old are raised for meat. The most common type of housing for broilers is enclosed housing with a compacted soil floor covered with dry bedding such as sawdust, wood shavings, or chopped straw. Mechanical ventilation is typically provided using a negative-pressure system, with exhaust fans drawing air out of the house, and fresh air returning through ducts around the perimeter of the roof.

Swine AFOs involve the breeding and growth of pigs for meat. Dairy AFOs produce milk. At many swine and dairy AFOs, manure handled as a slurry or liquid is stored in external earthen impoundments such as anaerobic lagoons. Lagoons are designed to hold the total volume of manure and process wastewater generated in addition to precipitation runoff. In the dairy industry, liquid-solid separation may be used to remove solids collected from run-off from ~~dry lots~~ ~~dry lots~~ and/or flushed manure from freestall barns and milking centers. The liquid from solids separation is sent to an external storage pond or anaerobic lagoon that is usually constructed as an earthen basin.

EPA developed EEMs for broiler confinement facilities and for open lagoons and basins at swine and dairy AFOs after reviewing data on emissions from two key sources: a) the National Air Emissions Monitoring Study (NAEMS), and b) data that EPA received in response to a Call for Information that EPA released that sought additional data on AFOs and emissions to ensure the agency is reviewing the broadest range of available scientific data. The NAEMS was a two-year study of emissions from AFOs

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1 that raise pigs and broiler chickens, and from egg-laying operations and dairies. The study was funded
2 | by the AFO industry as part of the 2005 voluntary air compliance agreement with EPA.

3
4 | EPA developed separate broiler ~~confined source~~confinement house EEMs for NH₃, PM₁₀, PM_{2.5}, TSP,
5 VOC and H₂S using NAEMS emissions and process information collected from one broiler operation in
6 California and from two broiler operations in Kentucky. EPA applied Statistical Analysis Software
7 | (SAS) to statistically evaluate ~~process~~parameters to determine if they were predictor variables that EPA
8 could use to develop the EEMs. Based on the results of EPA's predictor analysis, EPA's broiler EEMs
9 were developed using the following input parameters: bird inventory; ambient meteorological
10 parameters (i.e., temperature, relative humidity, and barometric pressure), and confinement parameters
11 (i.e., house temperature and relative humidity).

12
13 | EPA developed a swine and dairy lagoon open source EEM for NH₃ using NAEMS emissions and
14 process information collected from three dairies, three breeding and gestation swine farms, and three
15 | swine growing and finishing farms. EPA applied SAS to statistically evaluate the ~~process~~ parameters
16 and determine input parameters in a manner similar to that used to develop the broiler EEMs and
17 | developed its swine and dairy lagoon NH₃ EEM using the following input parameters: ambient
18 temperature, relative humidity, solar radiation and wind speed.

19
20 | EPA statistically evaluated the ~~process~~parameters using a mean trend function that provided a point
21 prediction of emissions under a given set of conditions. EPA chose a mean trend function to quantify
22 | the relationship between predictor variables and pollutant emissions by analyzing the emissions data-
23 EPA's EEM development process also involved choosing a probability distribution and covariance
24 | function to quantify other contributions to variability in emissions- and to provide estimates of
25 | uncertainty.

26 27 | B-2.2. SAB Review

28
29 During the summer of 2011, EPA requested the Science Advisory Board (SAB) to provide advice on
30 scientific issues associated with EPA's development of the EEMs. In February 2012, EPA developed
31 two draft documents ("Development of Emissions-Estimating Methodologies for Broiler Animal
32 Feeding Operations" and "Development of Emissions-Estimating Methodologies for Lagoons and
33 Basins at Swine and Dairy Animal Feeding Operations"). The documents provided to the SAB describe
34 the sites monitored, the data submitted to EPA, and a detailed discussion of the statistical methodology
35 used to develop the draft EEMs. EPA intends to use this same overall approach to develop draft EEMs
36 for egg-layer AFO facilities and swine and dairy AFO confinement houses.

37
38 EPA asked SAB to provide advice on EPA's overall approach for developing the EEMs. EPA also
39 requested advice on whether it should combine lagoon and basin data, whether it should use static or
40 dynamic predictor variables for its model, and how to handle data that were reported as negative or zero
41 results. In addition, EPA requested advice on alternative approaches for developing the NH₃ EEM for
42 | swine and dairy facilities and on whether it should develop an EEM for VOCs.

43
44 The SAB Animal Feeding Operations Air Emissions Review Panel (AFO Panel) reviewed the draft EPA
45 documents, considered public comments that were received on the draft Reports, and held a public
46 meeting on March 14, 15 and 16, 2012 to provide advice to EPA on the scientific adequacy, suitability

Suggested Changes to 9/28/12 Draft Report, for review and deliberations by the SAB Animal Feeding Operations Emissions Panel during the 10/24/12 teleconference call –

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1 and appropriateness of EPA’s draft Reports. The AFO Panel considered oral statements that were
2 received from the public during the public meeting and written public comments that were received on
3 the draft EPA documents. At the March 2012 public meeting, the AFO Panel raised several questions
4 and requested additional data which EPA responded to in separate documents submitted to the AFO
5 Panel in July and August 2012. The SAB held a follow-up public teleconference call on August 13,
6 2012 to review EPA’s responses and the additional data and consider whether EPA’s supplemental
7 responses changed any of the AFO Panel’s preliminary key issues and recommendations that were
8 raised at the March 2012 AFO Panel meeting. The AFO Panel held a public teleconference on October
9 | 24, 2012, to discuss substantive comments from Panel members on the draft SAB report-, “SAB Review
10 | of Emissions Estimating Methodologies for Broiler Animal Feeding Operations and for Lagoons and
11 | Basins at Swine and Dairy Animal Feeding Operations-.”

12
13 EPA plans to consider the enclosed SAB advice on the draft Broiler and Lagoons Reports and revise and
14 finalize these two documents and adjust its approach for developing EEMs based on SAB’s input. EPA
15 plans to develop draft EEMs for egg-layers, swine and dairy confinement houses and other pollutants for
16 swine and dairy lagoons/basins consistent with approaches that EPA will take when finalizing its Broiler
17 and Lagoons Reports, and submit Reports for these draft EEMs to the SAB for advice.

18
19 The Executive Summary highlights the SAB’s major findings and recommendations. The SAB’s full
20 responses to the charge questions are detailed in Section 3.

21
22

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3. RESPONSES TO EPA’S CHARGE QUESTIONS

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1 |

3.1–SPECIFIC CHARGE QUESTIONS

3.2.1.–EPA’S1. EPA’S APPROACH FOR DEVELOPING THE EEMS

Question 1: Please comment on the statistical approach used by the EPA for developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins. In addition please comment on the approach for developing draft EEMs for egg-layers, swine and dairy confinement houses.

Background:

EPA developed separate broiler ~~confined-source~~confinement house EEMs for NH₃, PM₁₀, PM_{2.5}, TSP, ~~VOE~~VOCs, and H₂S using emissions and process information collected from one broiler operation in California and from two broiler operations in Kentucky. EPA developed a swine and dairy lagoon-~~open source~~ EEM for NH₃ using emissions and process information collected from three dairies, three breeding and gestation swine farms, and three swine growing and finishing farms. EPA ~~applied~~used the Statistical Analysis Software (SAS) ~~package~~ to statistically evaluate ~~process~~ parameters to determine if ~~they were~~the predictor variables ~~that EPA~~ could ~~use~~ be used by the EPA to develop these EEMs. Based on the results of EPA’s predictor analysis, ~~EPA’s~~ broiler EEMs were developed using the following input parameters: bird inventory; ambient meteorological parameters (i.e., temperature, relative humidity, and barometric pressure), and confinement parameters (i.e., house temperature and relative humidity). EPA’s swine and dairy lagoon NH₃ EEM was developed using the following input parameters: ambient temperature, relative humidity, solar radiation and wind speed.

Overall RecommendationResponse:

In its review of the EEMs-, the SAB finds that a small number of broiler, swine and dairy facilities were used to develop the EEMs, and the EEMs developed from this limited sample are intended to be applied to AFOs throughout the country. The methods used in developing the EEMs are not well suited for extrapolation to conditions beyond those represented in the data set and therefore the EEMs cannot be assumed to be accurate predictors of emissions from other farms in the U.S. SAB concludes that EPA should not apply the current versions of the models for estimating emissions beyond those covered in the data set.

Statistical Approach:

SAB reviewed the statistical approach taken by EPA for estimation of air emissions from broiler confinement operations and dairy and swine lagoons. In addition, SAB will comment on the recommended approach for egg-layers, swine and dairy confinement housing.

A significant concern exists ~~about~~over the ability to use the EEM broiler and lagoon/basin models that were developed to extrapolate to other farms with reasonable accuracy. While the statistical approach to ~~the~~ analysis of the data may be acceptable for the small number of locations and limited range of conditions represented in the dataset, the EEMs are not well suited for extrapolation to conditions

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1 | beyond those represented in the ~~data-set~~dataset. Such extrapolations will be necessary if the EEMs are
2 | applied nationally. Further, some of the variables used for the model predictions do not make
3 | mechanistic sense. Using variables that are known to be logically or experimentally linked to the
4 | emissions (e.g., nitrogen content of litter to predict ammonia emissions) would seem more ~~physically~~
5 | plausible ~~and would be~~, more credible, and more likely to perform well across a broader collection of
6 | facilities ~~than the variables used by EPA in the draft EEMs~~.

7 |
8 | To make accurate predictions across farms, measurements would be required on a larger number of
9 | farms. Only ~~three~~two sites were evaluated for ~~poultry~~broiler operations, and they are unlikely to
10 | represent the industry as a whole. Only one site was used to estimate VOC emissions from
11 | ~~poultry~~broiler houses, and this was clearly not adequate to derive meaningful conclusions for the entire
12 | ~~industry~~ nationwide ~~industry~~. In addition, ~~only~~the six swine and three dairy lagoons ~~sampled~~ cannot
13 | represent all lagoons across both industries.

14 | Also, SAB cautions against the use of polynomial models when the use of the model is likely to extend
15 | beyond the range of data measured to develop the relationships since such models can lead to clearly
16 | erroneous predictions under certain production regimes employed in the U.S. (e.g., negative emissions
17 | or “near zero” emissions from large birds).

18 |
19 | SAB finds that most emission measures were over-weighted for periods of higher emissions such as
20 | during warmer weather, and the range in weather parameters for the dataset may not reflect the range in
21 | measurements across the country. The AFO Panel recommends evaluating the effects of weather on
22 | emissions and evaluating the ranges in weather patterns within the dataset relative to the industry across
23 | the U.S. ~~to~~ To determine how much of the data collected can be extrapolated to farms in different
24 | climatic regions. In general, ranges of data should be explained in the Reports and extrapolation beyond
25 | those limits should be counter indicated.

26 |
27 | An alternative to the current approach is ~~models that are more~~development of process-based models,
28 | however, this will be challenging with the existing NAEMS ~~data-set~~dataset.

29 | 30 | 31 | 32 | 33 | Process-basedBased Models:

34 |
35 | SAB strongly recommends that EPA develop process-based models of air emissions from AFOs of all
36 | types (e.g., broiler, dairy, egg layers, swine, etc.). This approach was recommended previously and
37 | described in detail by the National Research Council (2003). A process-based model would quantify the
38 | flows of materials from one process on a farm to the next (e.g., flows from feed through the animal
39 | housing to manure storage to field application and crop production). Rigorous process-based models
40 | would require consideration of emissions from each component of the farm system based on the
41 | concentrations and amount of reactants that lead to the emission from that component.

42 |
43 | For example, emissions from manure lagoons would be based on composition of manure, which would
44 | in turn depend on flows into and out of the manure lagoon. The flows into the manure lagoon would be
45 | derived from the manure production from the animal housing in the form of excreted feces and urine and

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1 bedding. Flows into a lagoon would also need to consider ~~the input~~inputs from the milking
2 ~~parlor,~~parlors and account for clean water collection from slabs and surfaces that may change the
3 volume and solids ~~ratio.~~~~The flows~~ratios. Flows out of the lagoon would be equivalent to the flows into
4 the field component as manure spread minus compounds emitted into the air ~~or,~~ leached, or mineralized
5 ~~through~~in the soil. Furthermore, ~~the~~mass flows in the manure lagoon would be quantified for each air
6 species of interest (e.g., NH₃, CH₄) based on the nutrient loading rates and concentrations of the
7 nutrients that lead to those species (e.g., urea, NH₄, organic N, organic carbon).
8

9 Process-based models could use additional data published in the literature, data that support key
10 literature, raw data from key studies, or data separately collected by EPA or other entities. These data
11 would need to measure the emissions from various components for the farm enterprise as a function of
12 variables that should matter based on a mechanistic understanding of the emissions. For example,
13 nutrients in animal manure could be estimated based on nutrient intake and production rates or at least
14 expected intake for a level of production. Nitrogen flows would be especially relevant to ammonia
15 emissions. The amount of urine and fecal nitrogen could be used to estimate emissions from the barn
16 floor or subsequent manure storage and application. The NAEMS data could be used to some extent to
17 evaluate accuracy of the process-based model.
18

19 Rigorous process-based models are data intensive; however, process concepts, such as limiting
20 predicted releases of nitrogen in emissions to be less than nitrogen inputs, can be used in simplified
21 models. Models of varying complexity should be developed (as EPA did with the proposed EEMs)
22 based on the level of input provided by a given producer (e.g., one model may be developed considering
23 the composition of a feed ration while a less complex model using default industry values could be used
24 if a producer does not wish to or cannot disclose information regarding feed rations).
25

26 The advantages of using a process-based model include the following:

- 28 • More existing data could be used, such as data ~~from~~for estimated emissions ~~for~~from a certain
29 component of the farm under certain conditions.
- 31 • Estimates derived would be more robust across different farm types.
- 33 • Control strategies could be developed for reducing emissions from farms based on implementing
34 technology standards or performance standards, wherein the standards would predict specific
35 impacts using the process-based models.

36
37 ~~These advantages would enhance the robustness of EEMs and ensure their applicability into the future~~
38 ~~rather than representing only a snapshot in time.~~

39
40 ~~Regardless of the approach that is used, uncertainty associated with the prediction at new farms should~~
41 ~~be evaluated.~~

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3.21.2. COMBINATION OF LAGOON AND BASIN DATA

Question 2: Please comment on the agency's decision to combine the swine and dairy dataset to ensure that all seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's comments on whether the agency should combine lagoon and basin data.

Background:

After conducting an initial analysis of the NAEMS data submitted for swine and dairy lagoons/basins, EPA began developing a draft EEM for NH₃. EPA's review of literature indicated that lagoon/basin emissions were influenced by several factors, including lagoon/basin temperature. To ensure that the dataset used to develop the draft EEM represented all seasonal meteorological conditions for the entire two--year monitoring period, EPA decided to combine the swine and dairy data that EPA relied on to develop the draft NH₃ EEM.

Response:

SAB recommends that EPA not combine swine and dairy datasets. The EPA justifies combining the swine and dairy data to ensure that multiple seasonal meteorological conditions are represented and a sufficiently large data set is available for analysis. Initial site selection for dairy lagoons in this study did not provide representation for measurements of all seasonal meteorological conditions. Neither ~~Moderate~~ moderate winters nor extended hot conditions in summer were represented. Although combining ~~data sets~~ datasets attempts to resolve problems associated with inadequate sample design by combining data from separate species, it should not be done, and it is not clear what inferences could be made from any resulting models.

Lagoons and basins are not the same and operate very differently. Treatment lagoons rely upon microbial populations to digest organic fractions of manure. Intermediary compounds are consumed by other populations of microbes. The net result is digestion and decomposition of organic matter. This process occurs more rapidly in lagoons than in basins. Differences in chemical composition and concentration between swine and dairy lagoons make it difficult (if not erroneous) to combine the data from these two sources. Combining species data without correcting for nutrient loading rates and chemical differences overlooks the basic differences in microbial processes and waste characteristics and undermines the credibility of conclusions drawn from such analyses.

Although the current EEM approach represents multiple seasons, little attention is paid to information on chemical, physical, and biological differences in the contents and functionality of the various lagoons and basins; ~~and~~ difference in species, production efficiency, diets, feed intake, animal stocking ~~density~~ densities, injection of fresh water, lagoon loading and many other factors. Inputs into lagoons/basins (loading rates for nutrients and chemical constituents) vary by facility and must be considered as these are feedstocks for microbial populations present in containment structures. More rapidly fermentable carbohydrates will be present in the swine manure. Different compositions of nitrogen and sulfur are also expected. Combined, these differences in influent concentrations will translate to differences in microbial decomposition activities, rates, and intermediary compounds, all

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1 influencing potential conversion to methane or non-conversion and potential release of emissions to the
2 atmosphere. Nitrogen quantity and composition in waste streams, pH, temperature at the interface
3 between the water surface and the atmosphere, and wind speed are known to play key roles in
4 volatilization of nitrogen as ammonia, yet none of these factors is considered in EPA's EEM.
5

6 It appears now, after the monitoring is done and the analysis is being undertaken by EPA to develop
7 EEMs, flawed approaches are being used to try to cover for flaws in the study design. EPA reports that
8 basin and lagoon data were combined to allow the estimation of basin NH₃ emissions in high
9 temperature ranges only measured in lagoons. Extrapolating basin NH₃ emissions to higher
10 temperatures based upon lagoon NH₃ emissions measured at higher temperatures is an example of such
11 erroneous analytical practice. This extrapolation assumes that basin and lagoon NH₃ emission
12 dependency on temperature is the same. Such an assumption is not known to be true. EPA should
13 clarify what other contributing factors to NH₃ emissions are different between the lagoons and the basins
14 that might affect NH₃ emissions. For example, clarify:

- 15 • Whether the basins developed any crusts or other solids on the surface which might obstruct
16 diffusion of NH₃ across the liquid/atmosphere interface.
- 17 • Dimensions of the basins and lagoons.
- 18 • Whether there are significant differences between lagoons and basins that would affect the wind
19 fetch and hence gas stripping effects of flow across the liquid/atmosphere interface.
- 20 • Whether there are pH differences.
- 21 • Whether redox potentials are similar.
- 22 • Whether any basins have anoxic surface layers.

23
24 The NRC ~~(2003)~~ report on AFO emissions concluded that emissions should be estimated based upon a
25 process-based model ~~(NRC, 2003)~~. If different treatment systems are going to be combined, the
26 process-based approach will be even more important. To do this, first the microbial processes must be
27 shown to be sufficiently similar. Once this is established, then it might be possible for EPA to identify
28 lagoon and basin ~~differences in waste characteristics such as~~ nitrogen, sulfur, and carbon concentrations;
29 residence time; temperature; pH; and other characteristics, and identify the range of data needed to
30 develop a nationally-applicable process-based emission ~~models~~model. This would require taking into
31 account how the microbial processes and the chemical and physical processes are controlled by
32 dominant characteristics in each system.
33

34 Developing a rigorous process-based EEM will require extensive data, beyond that available in the
35 NAEMS data set. To address this data gap EPA should consider using data collected through
36 mechanisms outside of the consent agreement, including data published in literature and data that
37 support key literature.
38
39
40

3.21.3. USE OF STATIC PREDICTOR VARIABLES

Question 3: Please comment on the agency's decision to use static predictor variables as surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that EPA consider specific alternative approaches for statistically analyzing the data that would allow for the site-specific lagoon liquid characteristics to be used as predictor variables?

Background:

To maximize the number of NH₃ emissions measurements used to develop the draft EEM, EPA used static predictor variables (SPVs) as surrogates for data on lagoon/basin conditions (i.e., nitrogen content of lagoon liquid, lagoon pH, oxidation reduction potential and temperature). EPA used the static variables of animal type, total live mass of animal capacity on the farm and the surface area of the lagoon to represent NH₃ precursor loading and the potential for release to the air.

Response:

SAB finds significant problems with EPA's approach of using ~~static predictor variables~~ SPVs as surrogates for data on lagoon/basin conditions. Such an approach would obscure key ~~emission~~ emission processes and variable interactions and fail to account for regional and inter-species variability among the fundamental drivers of emission processes. It would be inappropriate to extrapolate this approach to types of operations not represented by the study locations.

The SAB recommends that the functional relationships in any EEM should be based on the key drivers of emission processes.

Use of static predictor variables as surrogates for data on lagoon/basin conditions

To develop an EEM for NH₃ emissions from lagoons and basins at dairy and swine operations, EPA proposes to use SPVs such as total animal live weight and lagoon surface area, ~~derived by statistical regression techniques~~, in lieu of time-varying, lagoon- or basin-characterization data directly and fundamentally related to the respective emissions processes. Examples of the latter would include lagoon nitrogen loading, feed-to-gain performance (~~e.g.~~, for feeder pigs), and milk production (for milking herds).

~~Simplified to its essence, EPA's modeling approach takes the form~~

$$E_i = \sum \{ \beta_{ij} * SPV_j \} + \beta_{i0} + \epsilon_i$$

~~in which E_i is the emission rate of compound i, β_{ij}'s are regression coefficients, SPV_j is the jth SPV, β_{i0} is the regression intercept for compound i, and ε_i is the model's error term associated with compound i. The EPA model uses a combination of static and dynamic variables (meteorological), and interactions in the models they develop. In EPA's formulation, the SPVs may be either raw or transformed measurement data, depending on the individual variables' distributions. Because of the small number of farms relative to the number of static variables models, including all SPVs could not be considered.~~

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1 | Instead, several models are developed using subsets of potential static variables. Implicit in the
2 | modeling approach is the assumption that processes associated with NH₃ generation are able to be
3 | adequately modeled through linear statistical models.
4 |

5 | As presented in the draft EPA report, the SPV approach is problematic for a number of interrelated
6 | reasons:
7 |

- 8 | 1. To the extent that a given SPV is not clearly, unambiguously, and fundamentally related to the
9 | emission rate through a well-established emissions mechanism – the resulting EEM cannot be
10 | reasonably extrapolated to other ~~livestock operations-AFOs~~. Given EPA’s desire to use the EEM
11 | on facilities across the ~~United StatesU.S.~~, the model should account for the wide variation in
12 | design, climate, and management factors across the ~~United StatesU.S.~~
13 |
- 14 | 2. Several of the SPVs that EPA selected for its EEM are individually deficient. For example:
15 |
 - 16 | a. ~~BasinLagoon~~ surface area – in the case of ~~basinsstorages~~ that are managed as anaerobic
17 | lagoons and that therefore maintain a relatively constant depth ~~of material~~ over time,
18 | ~~basinliquid~~ surface area would be a reasonable SPV. However, design and management
19 | factors – both of which are site-specific – determine whether or not a given ~~basinstorage~~
20 | actually maintains a constant depth. In the general case, particularly where ~~basinsstorages~~
21 | have sloping sides, small changes in depth can translate into large changes in surface area,
22 | even within a span of hours to days.
23 |
 - 24 | b. Animal numbers – it is reasonable to suppose that nitrogen loading to a basin scales by
25 | animal numbers provided that all other feed-intake, retention/milk production, and
26 | management variables remain static. But that (highly contingent) scalability ought not be
27 | taken to mean that animal numbers represent a fundamental variable driving NH₃ emissions.
28 | In the case of dairies, for example, milking herds may be managed according to productivity,
29 | feeding higher-energy, higher-protein diets to higher-producing cows, and vice-versa.
30 | Simply doubling herd size, without knowledge of the feed intake, performance, management
31 | factors associated with the additional animals, and the degree of solids separation does not
32 | necessarily double the emissions attributable to the per-animal emissions processes; but that
33 | is what the SPV approach implicitly assumes.
34 |
- 35 | 3. Dairies and swine operations differ substantially and in ways that cannot reasonably be collapsed
36 | into a single pseudo-species. Because nitrogen loading to a lagoon or basin – a key driver of
37 | NH₃ emissions – is driven in large measure by feed composition, feed intake, nitrogen retention
38 | (for swine operations), and milk production (for dairies), among other key variables, inter-
39 | species effects on diet and the manure produced must be taken into account in SPV evaluation.
40 | Swine and dairy EEMs should be individually formulated.
41 |
- 42 | 4. The range of climatic, management, feeding, and animal-performance conditions represented by
43 | the livestock operations in the NAEMS study is too narrow to provide reliable emissions
44 | estimates across the full range of conditions in which dairy and swine producers operate in the

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1 | ~~United States~~U.S. For example, the ~~data sets~~datasets used in the NAEMS study do not represent
2 | moderate winters or extended, hot summers.
3 |

4 | In summary, EPA has attempted to overcome serious deficiencies in the NAEMS ~~data sets~~datasets by
5 | appealing to a statistical analysis that obscures key ~~emissions~~emission processes and variable
6 | interactions, that fails to account for regional and inter-species variability among the fundamental
7 | drivers of emission processes, and that cannot reasonably be extrapolated to types of operations not
8 | represented by the study locations. ~~In lieu of EPA's approach to EEM development, the~~The SAB
9 | recommends that EPA move in the direction of a ~~more~~ process-based approach that uses appropriate,
10 | physically-based, region- and species-specific variables.
11 |
12 |

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1 Alternative approach for statistically analyzing the data

2
3 A statistical model developed from limited data will not provide a satisfactory EEM for use beyond the
4 dataset from which it was created. An alternative to the statistical approach proposed by EPA is to
5 develop a functional relationship based upon scientific understanding of the principles involved in the
6 emission process and then use a statistical procedure to help quantify the required parameters. This
7 must begin by identifying the appropriate dependent and independent variables. For ammonia emission
8 from a manure lagoon or basin, for example, the predicted variable should be the emission per unit
9 surface area of the lagoon or basin. The independent variables must include both weather conditions
10 and manure characteristics. Important weather variables that must be included are ambient temperature
11 and wind speed. Solar radiation and precipitation may also contribute and should be used if the data are
12 available. Important manure characteristics include dry matter and nitrogen concentrations. The
13 organic and inorganic nitrogen contents would also be helpful if that information is available. Other
14 important manure characteristics include pH and temperature (if it is different from ambient
15 temperature). Management can affect the amount of crusting that occurs on the manure surface, and a
16 surface crust can reduce emissions from 20 to 80% depending upon the thickness and uniformity of the
17 crust across the surface. If the appropriate manure characteristics are defined and used, the manure
18 source (e.g., dairy, swine, and poultry) ~~should~~would not be important. For all of these variables, the
19 temporal resolution of the data should be consistent with the time scales on which the variables are
20 changing. For example, ~~Manure~~manure characteristics will not change rapidly, so hourly or daily data
21 are not needed for these variables.---

22
23 The functional form of the predictive relationship must be established based upon the biological,
24 chemical and physical processes driving emissions. As the independent variables approach maximum
25 and minimum potential values, predicted emissions must also approach appropriate values (i.e., emission
26 predictions must approach zero under the appropriate conditions and approach some maximum value at
27 the outer extremes). Unreasonable predictions such as negative or infinite values cannot occur. Most
28 often this will require nonlinear relationships. The functional relationship must allow an appropriate
29 prediction across the full possible range of each independent variable and combination of variables that
30 might be used. Only this type of relationship can be used to extrapolate to conditions outside the
31 original dataset. An EEM that is applied to all manure storages throughout the country must be
32 satisfactorily applied to conditions beyond the limited data from which it was developed.

33
34 After the functional form of the relationship is established and the appropriate independent and
35 dependent variables are included in that function, a statistical approach can be used to help quantify
36 parameters along with scientific understanding. Somewhat limited data can be used to determine
37 parameters that should be appropriate beyond the bounds of the original data. Extensive verification is
38 required across the full range of possible conditions and some parameter adjustment may be needed to
39 avoid inappropriate predictions outside the bounds of the original data. Therefore, statistical accuracy
40 relative to the original data may be sacrificed to assure a full range of appropriate predictions. The
41 NAEMS data should provide an appropriate dataset for model parameterization, but other data and
42 published information should be used for establishing the structure and parameters of the EEM and
43 evaluating that EEM for more diverse conditions. This level of rigor in EEM development and
44 evaluation is necessary ~~for national use~~to develop a nationally-applicable EEM.

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3.21.4. ALTERNATIVE APPROACHES FOR NH₃ EEM

Question 4: Does the SAB recommend that EPA consider alternative approaches for developing the draft NH₃ EEM that balances the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions. If so, what specific alternative approaches would be appropriate to consider?

Background:

EPA requested SAB advice on alternative approaches for developing an NH₃ EEM that would balance the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions.

Response:

The SAB recommends that EPA consider alternative approaches for developing a NH₃ EEM, since the NAEMS data are limited, and since EPA's goal is to develop an EEM that would be broadly applicable across the U.S. for determining emissions from lagoons. There are several options that EPA should consider to enhance their ability to develop a better EEM:

- ~~Reconsider the 75% completeness~~ Completeness goals for data. The draft Report states ~~is stated~~ that, "A valid monitoring day is one in which 75% of the hourly average data values used to calculate the daily value were valid measurements. An hourly average is considered valid if 75 percent% of the data recorded during that hour were valid." EPA should clarify why the ~~goalscompleteness goal~~ of 75% ~~of the hourly average data values werewas~~ deemed critical for determining an hourly average. EPA should also clarify whether it limited this criterion to 75% of the raw data or to 75% of the two 30-min averages. EPA should consider whether or not this criterion is too stringent, given the data limitations. If- collected data were of good quality during a particular hour interval, ~~it would be wise to~~ EPA should include these data as there are already many gaps in the data used for the development of these EEMs.
- The goal of having 75% of the hourly averages in order to have a valid monitoring day may be biasing and limiting the dataset. A 75% completeness goal means that as many as 6 hours of data could be missing in a day, and it is important to know when data are missing and whether the missing data would bias the daily average. For example, if data were consistently missing at a time period when the emissions might be high or low, then the overall average may be biased in one direction or the other. It is important to note if the missing hourly values were random or if they occurred in some discernible pattern. In addition, EPA should consider using methods to "gap fill" missing data. In many cases, emissions follow very distinct patterns and it is possible to fill in missing data using interpolation or other algorithms that would increase the number of "valid days" available for analysis.
- ~~Consider using the emissions~~ Emissions estimated using the bLS method. Since there is a paucity of data in the current dataset, SAB recommends that EPA ~~should~~ consider using the bLS data

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1 | either instead of the RPM data or in conjunction with the RPM data. There are ~~actually~~ two
2 | points to consider here. The first point is the decision to use 30-min emission values, as opposed
3 | to using daily values. While doing this does ~~results~~ result in a greater number of data points, the
4 | use of daily averages may better capture emission trends. As there are large diurnal emission
5 | patterns in any given day, this may overshadow predictor variable effects or add more “noise” in
6 | the analysis. As stated above, if the 30-min averages are from time periods when the lagoon
7 | emissions are typically high or low, this could affect the overall EEM estimate, whereas using a
8 | daily emission value may eliminate that potential problem. Additionally, the real drivers of
9 | emissions (i.e., lagoon chemistry and biology) change slowly (more in terms of weeks or months,
10 | not minutes), therefore it might be better to use daily values in conjunction with the available
11 | lagoon chemistry data to build more powerful models (more on this point below).
12 |

- 13 | • ~~The second point deals with the justification for using the~~ There is no scientific reason to rely on
14 | RPM-generated data- ~~over~~ bLS-generated data. As stated in the EPA ~~reports~~ report: “The EPA
15 | used the RPM data because these measurements were obtained using instrumentation and
16 | procedures that were similar to EPA’s developmental test method OTM-10. The EPA did not
17 | use the bLS emissions measurements because these data were collected under the NAEMS to
18 | conduct a validation study of the bLS model performance relative to the RPM model.
19 | Furthermore, because the RPM emissions dataset is much larger than the bLS dataset, including
20 | the bLS measurement in the EEM development dataset would not provide any additional
21 | information on lagoon emissions.” If daily values are used then the bLS dataset has 285 valid
22 | days as opposed to only 69 valid days using the RPM model. There is no scientific basis for
23 | using the RPM dataset over the bLS dataset. This is in no way a validation study for the bLS
24 | model. In order to conduct a validation study, the true emission values from the source should
25 | be known. Because the true emissions are not known from any of the open area sources, it
26 | would not be possible to establish which model performed better and which model produced an
27 | emission rate closest to the true rate. Therefore, one cannot draw ~~any~~ conclusions as to which
28 | model more closely estimated the true emissions from the source. Based on the few published
29 | validation studies available, the bLS model has performed very well for open area sources. ~~One~~
30 | (Ro et al., 2011, 2012) found that the bLS model more accurately predicted emissions from open
31 | sources than the RPM model (~~Ro et al., 2011; Ro et al., 2012~~). In several of the
32 | ~~publications~~ datasets collected in the NAEMS study the RPM and bLS emissions estimates were
33 | very close, therefore it might be possible to fill in missing days by combining the two datasets
34 | and eliminating the overlap. This would result in more available days for use in the development
35 | of the model.
36 |

- 37 | • Units of emissions estimates. Use of proper units to express the emissions estimates is also a
38 | concern. The draft EEMs use kg/30-~~min~~ ~~as~~ min as the unit of emissions, but perhaps better
39 | relationships could be developed if EPA used kg/ha-~~or~~, kg/live*~~-~~wt, or some other denominator
40 | that captured the physical differences ~~of the~~ between operations. These variables (lagoon size
41 | and animal weight) were included as predictor variables, but it would potentially be better to
42 | account for these in the emission unit, therefore eliminating the need to have them as a predictor
43 | variable, ~~which would use less degrees of freedom~~.
44 |

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- 1 | • Use of available lagoon chemistry data. ~~At present~~In the draft EEMs, the predictor variables
2 | chosen to estimate emissions are inadequate. The factors that actually drive the emissions (i.e.,
3 | lagoon characteristics) were not included in any of the analyses. It seems highly unlikely that a
4 | suitable methodology could be developed to predict NH₃ emissions across the country when (at a
5 | minimum) the nitrogen content and pH of the lagoon have not been included as variables in the
6 | model. The model should also consider the potential effects of surface crust on emissions. Some
7 | of the predictors chosen such as temperature, day of year, and wind speed would certainly have
8 | an impact on emissions, but due to differences in lagoon composition and chemistry, the effects
9 | would be farm specific and not translatable to other farms. For instance, it is possible to have
10 | two farms in the same area, with the same number of animals and same meteorological
11 | conditions that have greatly different emissions due to differences in the pH and nitrogen content
12 | of the lagoon, ~~as well as preceding manure management system.~~ There does seem to be both
13 | nitrogen and pH data available for four of the farms, representing approximately 46% of the 30-
14 | min emissions estimates used in the models. If daily emissions estimates were used and the
15 | lagoon chemistry data were extrapolated to other days, there may be a suitable dataset that could
16 | be used to develop ~~ana~~ **more robust** EEM using both the lagoon characteristics as well as ~~the~~
17 | meteorological data, ~~data; the resulting EEM is expected to be more robust.~~ The SAB finds that
18 | developing an EEM that incorporates ~~the~~ lagoon chemistry, meteorological, and farm data would
19 | be much more valid than relying on weather data and static predictor ~~farm~~ variables alone, even
20 | though the dataset would be smaller.
21 |
- 22 | • Biological thresholds. One other concern related to the development of the EEMs using the
23 | current technique is that there is no recognition of realistic biological thresholds. Estimates from
24 | any ~~models~~ **model** should not violate biological boundaries (~~i.e.g.~~, one cannot emit more nitrogen
25 | than is present). There should be some upper and lower threshold limits to ensure that, ~~the~~
26 | methodology alone would not result in an estimated emission rate that is not realistic. SAB also
27 | recommends that EPA compare the results of the EEMs that it develops with emissions
28 | documented in available literature. There are a number of models available that are used to
29 | estimate NH₃ emissions. One could use the nitrogen and weather information available for the
30 | lagoons, attempt to calculate emission rates and compare ~~that~~ **those** with published emission
31 | estimates from the literature.

33 | 3.1. Primary and secondary units

34 | ~~Emission unit~~ **Selection of appropriate units to express emissions** is influenced by the type of facility and
35 | final use of the data. Primary emission units are directly from the measurements on-farm with
36 | secondary units available based on parameters collected to allow conversion from one emission
37 | expression to another. The uncertainty associated with the measurements needs to be reported ~~(see.~~
38 | **Refer to Wheeler et al. (2010) “Recommended Units and Supporting Data for Standardized Reporting of**
39 | **Air Emissions from Animal Agriculture” a White Paper for Natural Resource Conservation Service**
40 | **(NRCS)). (also see Xin et al. (2010) NRCS White Paper “Methodologies and Protocols for Analysis of**
41 | **Raw Data to Minimize Uncertainty of Resultant Emissions Estimation” for details of uncertainty**
42 | **analysis and expression).** The following are five potential expressions of Emission Rate (ER), defined

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1 as contaminant mass per unit time for types of source. Some examples are provided for situations in
2 which they are most useful.

3
4 1. Per Farm (e.g., ER/500-cow-dairy);~~→~~)

5 -Not commonly used due to complexity of accounting for all emission sources under various
6 management options, weather, and geographical differences.

7
8 2. Per Unit of Area (e.g., ER/m²) for animal housing, open lots, manure storage, and feed storage;~~→~~ ~~most~~
9 -~~Most~~ common for emissions that do not originate from a fully enclosed building.

10
11 3. Per Animal Unit (e.g., ER/bird) for animal, place (i.e., # stalls), body weight, productive animal [“per
12 milking cow” = lactating/dry cow + her replacements];~~→~~]

13 -Very commonly used for enclosed buildings or where the animal population is relatively stable
14 in both number and body weight.

15
16 4. Per Unit of Food Product (e.g., ER/lb pork, gallon of milk, dozen eggs, or weaned piglet) for final
17 food product or animals marketed;~~→~~

18 -Increasing in use as animal agriculture has become more efficient in product produced with
19 reduced animal population.

20
21 5. Per Inputs (e.g., ER/kg nitrogen fed);~~→~~)

22 -Best use in models and pollutant mitigation where the biological, chemical, and management
23 influences can be fairly evaluated.

3.21.5. COMMENTS ON APPROACH FOR HANDLING NEGATIVE AND ZERO DATA

Question 5: Please comment on the EPA's approach for handling negative or zero emission measurements.

Background:

Some NAEMS emissions measurements were reported as either negative or zero emissions values. EPA considered whether to include these negative and zero emissions values in the data used to develop the EEMs. EPA evaluated whether the negative or zero values represented variability in emissions measurements due to instrument/equipment performance. EPA also reviewed the data to see if the data quality measures were properly performed according to the Quality Assurance Project Plan. EPA concluded that all negative values should not be considered in the development of the EEMs.

Response:

1. Overview

There are two types of data assessed in EPA's Reports: directly measured air pollutant concentrations and calculated air emission rate values. In both cases, EPA must address negative and zero values. In the draft EEMs, EPA has withheld the negative values in their EEM development process and kept the zero values. SAB has reviewed EPA's treatment of these values and provides the following suggestions for the handling of negative and zero data for both direct concentration measurement and calculated emission values.

2. Negative values

There was a relatively small number (<1.7% for broiler and <2% for swine and dairy lagoon data) of negative data points, but their inclusion in the model is important. Negative values appear in both direct concentration measurements and calculated air emission rates. SAB's suggested approaches for handling the negative values are discussed in the following sections.

2.1. Direct Air Pollutant Concentration Measurement Values

Except in a few possible situations, negative measures of concentrations are problematic. In general, a negative concentration measurement value can occur due to a true value that is at or below the minimum detection level (MDL), instrument measurement error, a measurement value that is adjusted by the equipment calibration offset procedure, and instrument fluctuation due to influence by ambient conditions. Each of these cases is considered individually.

Minimum Detection Level and Instrument Error. From a statistical point of view, the correct approach for dealing with negative values is to recognize that those values are censored. That is, it is known that the measured value is below the instrument's minimum limits of detection, but above zero (a true

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1 | concentration can never be below zero). As long as the rest of the variables associated with that
2 | measurement are known (e.g., time of data collection, location, and source type), these censored values
3 | should be included in all statistical analyses. In practice, different approximations for dealing with
4 | censored responses are often proposed in lieu of the implementation of censored data methods. For
5 | instance, if the instrument produces a negative concentration value ~~that is~~ due to a “below detection” or
6 | “minimum detection limit” reading, but ~~it is~~ within instrument uncertainty boundaries, the measured
7 | value should be used. However, if the measured concentration value is not within acceptable instrument
8 | error, then the value should be removed from ~~data set~~the dataset. Suggestions on the treatment of
9 | negative values from instrument ~~are as follows~~:

- 10 | • Use the negative value produced if it is within instrument error.
- 11 | • Use the EPA procedure of using half of the MDL when the observed value is below the MDL.
12 | (Theoretically this method is better, but ~~it is~~ also very difficult to differentiate the negative values
13 | that are due to calibration offset from those that are below the MDL. ~~Accept all negative values
14 | that are deemed valid as is.~~)

15 | •
16 | *Calibration Offset.* Negative values can arise due to instrument “noise” or adjustment of calibration
17 | offset, which is calculated based on the average zero and span values over a period of time. The
18 | negative gas concentration values attained during offset correction should generally be very small in
19 | comparison with the mean measurement values. Due to the nature of equipment noise, the resulting
20 | measurement values can be both positive and negative. Since there is no way to identify the positive
21 | noise, the negative noise measurement should be kept for non-biased statistical analysis.

22 |
23 | *Ambient Influence.* Variability in instrument measurements can result from variations in ambient
24 | conditions (~~i.e.~~, atmospheric stability) resulting in overestimated positive or negative values. The bias,
25 | either positive or negative, will depend on the instrument type (particulate matter or gas) and ambient
26 | condition. For example, in the measurement of particulate matter (PM) from broiler confinement
27 | housing, negative PM concentrations can occur due to short term fluctuations in relative humidity which
28 | causes fluctuation in the real-time TEOM PM concentration measurement process. When the air
29 | humidity increases, the TEOM measurement will have an increased bias. If the air humidity decreases,
30 | then the TEOM measurement bias will decrease, and a negative PM concentration can possibly occur.
31 | Since it is very difficult to identify and quantify the positive bias, the negative bias measurement should
32 | be kept for non-biased statistical analysis. Additionally, when measuring the concentration of gas
33 | emissions from dairy and swine lagoons, the influence of wind speed and direction can also cause a bias
34 | in the data ~~set~~by influencing the plume direction and velocity. For instance, when wind velocity is
35 | negligible, the emission plume will be closer to vertical, resulting in very low concentration
36 | measurements, possibly below the MDL. Variable wind direction can also move the plume out of the
37 | measurement pathway and cause depressed measurement values. In all cases, negative values can arise.
38 | ~~These~~ When these values are a limitation of the measurement technique, ~~they~~ should be screened for
39 | validity, and likely excluded from the dataset. In all cases, the negative values that are produced from
40 | ~~these~~ situations ~~described above~~ will introduce a bias ~~to the dataset, (that is likely small) to the data~~
41 | ~~set~~. If excluded from the ~~data set~~dataset, standard errors of estimated model parameters will be
42 | underestimated and, consequently, confidence intervals around, ~~for example,~~ predicted concentrations,
43 | ~~for example,~~ will be too narrow, indicating a precision that is higher than what it should be.

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~~In all cases, the negative values that are produced from the situations described above will introduce a bias to the data set, likely small. If excluded from the data set, standard errors of estimated model parameters will be underestimated and consequently, confidence intervals around, for example, predicted concentrations, will be too narrow, indicating a precision that is higher than what it should be.~~

Overall, it is important to qualify unexpected observations individually and to understand and document why an observation is negative. In some cases, it will be decided that the measurement is the result of operator error, instrument failure, instrument drift or some other factor. In these cases, and absent additional information that might permit correcting the measurement, observations should be discarded.

2.2. Calculated Emission Rate Data

Air emission rates were calculated by subtracting the measured background concentration value from the directly measured concentration value, and multiplying by the airflow rate. In cases in which that calculated value was negative, the EPA decided not to include it in the model because they thought it suggested that the area in question (i.e., confinement houses, lagoon), was acting as a sink (EPA, 2012, pg 3). SAB concludes that negative calculated emission data should be included in the model under certain conditions.

Negative calculated emission values can arise from the following scenarios:

- In this study, the background and source measurements were measured either intermittently (twice a day for gas), or continuously without correction for lag time in the barn (PM data), thus leading to a bias either up or down, introducing the potential for negative emission values. Because bias could occur in either the positive or negative direction, negative calculated emission values should be retained in the ~~data set~~dataset, as long as their individual measured value was already validated. Omitting these data would bias the model in the upward direction. The true estimated value is more accurate if all calculated values are included.
- A calculation bias may also occur when the measured values are at or near the detection limit, or negative. Calculation of negative emission rates due to small or negative values should be very small, and should be kept.
- In some scenarios, outdoor events may affect the background concentration. For example, if there was activity outside the poultry barn which resulted in increased pollutant concentration (e.g., other barn cleanout and manure movement), the measured background values would be biased upwards, and subsequently, the calculated emission value may become negative. Alternatively, a positive bias could occur if meteorological conditions caused the exhaust air to come back into the barn, thus influencing the measured concentration. In these situations, errors caused by special abnormal outdoor events should be identified and removed from the study results if appropriate.

Negative emission rates can be used to develop a model that never predicts negative emissions. In some cases, these negative emission rates may be necessary to appropriately describe the uncertainty of the model. If the prediction model excludes negative values, predictions at low emission rates will be biased, thus weakening the case for use of the EEM.

Overall, SAB suggests that if the measured concentration data are validated and included in the ~~data set~~dataset, then the emission value calculated from that ~~data set~~dataset is also valid, whether it is negative or positive.

Suggested Changes to 9/28/12 Draft Report, for review and deliberations by the SAB Animal Feeding Operations Emissions Panel during the 10/24/12 teleconference call –

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2 3. Zero values

3 Zero values are present in the direct measurement data as well as in the calculated emissions ~~data~~
4 ~~setdataset~~. The following discussion provides SAB's recommendations on how to address zero values.

5

6

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1 *3.1. Direct Air Pollutant Concentration Measurement Values*

2 If during measurement, or after instrument calibration, the resulting measurement is zero, SAB
3 recommends that the value ought to be used in statistical analyses. However, few instruments have the
4 precision needed to distinguish a true zero from a small value; consequently, zero measurements will
5 often correspond to censored observations and thus should be treated as such. The use of zero values in
6 the model is likely to produce small biases in both the estimated regression coefficients and their
7 standard errors.

8 *3.2. Calculated/Emission Data*

9 After elimination of invalid data, if a calculated emission value is zero, it should be included in the ~~data~~
10 ~~set~~dataset. There are many cases in which emissions of a given pollutant may be zero from a particular
11 source and should be included in any analysis. Overall, if the emission value, calculated from valid
12 data, is zero, then that value should always be included in the model.

13

14 *4. Outliers*

15 EPA did not ~~subject the data to apply formal statistical outlier test~~tests as part of the modeling process;
16 rather, EPA applied standard procedures (control charts and custom software) to flag data believed to be
17 outliers (EPA, 2012, pg 2) as part of the data verification process. SAB suggests that outlier analysis
18 procedures be conducted-

19 ~~An outlier is an observation that appears to be different from the other observations in the sample. The~~
20 ~~definition of what makes an observation an outlier is observer dependent; what appears to be an outlier~~
21 ~~to one individual may appear to be unremarkable to another.~~

22 ~~Outliers can arise for various reasons. Typically, outliers result from faulty measurements, unusual~~
23 ~~conditions, or data entry error. However, outliers can also indicate the existence of legitimate events~~
24 ~~with very low probability. If the former, outliers ought to be corrected if possible and discarded~~
25 ~~otherwise. If the latter, outliers can provide useful insight into the process and lead to revised sampling~~
26 ~~and modeling approaches.~~

27 ~~Unfortunately, it is sometimes difficult to determine whether an outlier is due to a mistake or whether it~~
28 ~~is an unusual observation with low probability. In those cases, two analyses are often presented, one~~
29 ~~including and one excluding the outliers, so that users get a sense as part of the differences in the final~~
30 ~~conclusions of the analyses that result as a consequence of the unusual observations.~~

31 ~~In summary, outliers should be first treated per the QA/QC process to determine (if possible) their origin~~
32 ~~and then included or not in the analyses with a clear explanation for the decisions made by the~~
33 ~~analyst~~model building process.

34

35 *5. References*

36 EPA. 2012. Attachment A: Discussion of Negative Emissions Values for Broiler Confinement Houses
37 and Swine and Dairy Lagoons/Basins.

38

39

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1 | **3.21.6. ALTERNATIVE APPROACHES FOR NEGATIVE AND ZERO DATA**

2 |
3 | *Question 6: In the interest of maximizing the number of available data values for development of the*
4 | *draft H₂S EEMs for swine and dairy lagoons/basins, does SAB recommend any alternative approaches*
5 | *for handling negative and zero data other than the approach used by the agency.*

6 |
7 | **Response:-** It is understood that the dataset for hydrogen sulfide (H₂S) for swine and dairy
8 | lagoons/basins was small due to data summary methods and/or instrument deficiency in being able to
9 | record concentration/emission values and producing invalid data for H₂S. Instrument deficiency was
10 | due to changes in wind direction, inadequate wind speeds, or other unknown variables. This cannot be
11 | corrected for after the fact. The EPA Reports should fully discuss the occurrence and reasons for the
12 | lack of sufficient data and large amount of poor quality data.

13 |
14 | The summary methods used by EPA ended up precluding data if ~~at~~ the 75% ~~validation~~completeness level
15 | for various time periods (i.e., hourly, daily, total) was not met. The 75% ~~number~~completeness criterion
16 | seemed too stringent and unnecessary in this case and it is suggested that the number be evaluated for
17 | reduction or removal so that more data can be included. To maximize the ~~data set~~dataset, it is
18 | recommended that all data meeting the criteria outlined in Charge Question #5 be included for analysis,
19 | regardless of the 75% completeness criterion.

20 |
21 | See response in Charge Question 5 for general recommendations for handling negative and zero data for
22 | any ~~data set~~dataset.
23 |
24 |
25 |

1 **3.21.7. BROILER VOC EEM**

2
3 *Question 7: Please comment on the approach EPA used to develop the draft broiler VOC EEM.*

4
5 Background:

6
7 EPA reviewed the volatile organic compound (VOC) data submitted for the California and Kentucky
8 broiler sites. The two sites used different VOC measurement techniques. Based on analysis of the
9 measurement and analytical techniques and the VOC data, EPA used only the VOC data from the
10 Kentucky sites when developing the draft VOC EEM.

11
12 Response:

13
14 SAB has identified significant limitations with the broiler VOC data, and concluded that the broiler
15 VOC data cannot support the development of a broiler VOC EEM at this time.

16
17 Under the Consent Agreement, EPA is required to provide an EEM for daily and annual VOC
18 emissions; however, there is a provision in the Consent Agreement that, if the SAB decides that the
19 available data are not adequate to support development of the EEM, the EPA can delay development
20 until adequate data are available (see *Federal Register* Notice Volume 70, Number 60, Pages 4958-
21 4977, published on January 31, 2005). Limitations of the broiler VOC data include:

- 22
23 - The procedures used to collect VOC data at Site CA1B (i.e., THM analyzer with photobooster)
24 did not produce useful data for model development and should not be used in development of an
25 EEM. Therefore, data from only two farms in one geographic region (KY1B-1 and KY1B-2) are
26 available to EPA through the NAEMS study.
- 27
28 - Canisters, which can only be used to assess a limited suite of compounds, were used to sample
29 VOCs. Other sampling techniques are required to gather other VOCs that cannot be analyzed
30 using canister analysis.
- 31
32 - From Site KY1B, VOC recovery rates from the canister are unknown as not all compounds are
33 able to be extracted from electropolished canisters onto sorbent tubes, and sorbent tubes were not
34 utilized for direct collection of VOCs.
- 35
36 - Sampling at Site KY1B was conducted quarterly over a 21-month period (i.e., seven collection
37 events), during which time two samplers were placed at the exhaust fans of each of two facilities.
38 However, background samples were not collected at the inlet of the barns, so no data were
39 available from which to determine the net increases in VOC concentrations attributable to the
40 housing facilities.
- 41
42 - VOC concentration data from Site KY1B are limited to the specific climate and management
43 conditions of the site and cannot be applied to all production facilities across the U.S. with a
44 reasonable degree of confidence regarding their representativeness.

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Based on these concerns, SAB recommends that EPA not generate an EEM for VOCs from broiler operations at this time.

Although the NAEMS ~~data set~~dataset is too limited to produce an EEM, valuable components of the VOC data should be reported. Based on EPA’s presentation of KY1B VOC data, those data appear generally valid and usable if (and only if) the methods used to collect VOC data are more extensively and clearly documented than in EPA’s first draft report. In the draft report, the agency reported in detail how data were *supposed* to be collected at both sites, but details of how and what data were *actually* collected were incomplete and unclear. EPA should state unambiguously what data were actually collected from each site, how they were collected and analyzed, and what data passed QA/QC criteria checks. Data collected absent strict adherence to SOP and QAPP, including equipment calibration methods, are not valid and should be identified as such.

Data reported by the EPA should include total and speciated VOC concentrations to provide general information on broiler emissions from the sites where data were collected. Moreover, “Total VOCs” should be explicitly defined to clarify whether reported values represent the sum of all VOCs analyzed or the total VOCs quantified by the analyzer, which will capture only a portion of all VOCs present in a sample. These data may help identify important compounds emitted from broiler facilities, which can help guide future data collection efforts. An indication of the magnitude of VOC concentrations relative to any reports of background VOC concentrations reported for this region would help, qualitatively, to identify those compounds that appear to be emitted in substantial quantities from the CAFOs. One challenge with the incomplete data collection is how EPA determines if “substantial quantities of compounds are emitted” when ~~the~~entire VOC suite emitted is not quantified;~~when~~. When such quantification does not occur, it is not possible to identify if one compound or another is a substantial component of ~~VOC~~the VOCs emitted. Also, the determination of what is ~~‘substantial’~~“substantial” is subjective without a numeric qualifier. After reporting the available data, the EPA should defend the decision to not develop an EEM given the limited information available and the uncertainty of the data collected in the NAEMS. In order to develop an EEM for VOCs, a comprehensive investigation from existing scientific literature and future research regarding what factors drive generation of VOC emissions from broiler facilities is necessary to lay the foundation for development of a process-based model for estimating emissions from these operations.

4. SPECIFIC RECOMMENDATIONS FOR EPA’S DRAFT REPORTS

The SAB provides the following general comments on EPA’s two draft documents related to animal feeding operations emissions: “Development of Emissions-Estimating Methodologies for Broiler Animal Feeding Operations” (i.e., Broiler Report), and “Development of Emissions-Estimating Methodologies for Lagoons and Basins at Swine and Dairy Animal Feeding Operations” (i.e., Lagoon Report). SAB considered whether the draft Broiler and Lagoon Reports were presented in a clear, comprehensive, and scientifically sound manner.

Overall, SAB finds that both Reports should be updated to describe the importance of retaining a long-term goal for producing process-based models. The SAB also concludes that the Reports should more comprehensively describe data completeness, representativeness, ~~and~~ limitations, and whether there are sufficient data to begin a process-based modeling approach. In addition, SAB recommends that the discussions on mechanisms of data collection, ~~including pollutant concentrations~~, ventilation rates within barns, and feed composition and quantity should be enhanced in the Reports. Furthermore, the Reports should more fully explain why any of the NAEMS data were excluded from EEM development. Since NAEMS data have significant limitations, the Reports should include an assessment that considers use of additional data that were not collected as part of the NAEMS data collection effort.

Specific SAB recommendations for each draft report, beyond those made in response to the charge questions, are noted below.

4.1 Draft EPA Broiler Report

SAB recommends that EPA reorganize the report and rewrite several sections to address various concerns of the SAB. EPA should develop a process-based modeling approach to make predictions of air emissions on broiler farms, and incorporate that approach into the report. EPA should also make a number of improvements to the statistical approach for developing EEMs. In particular, EPA should describe methods for calculating confidence values to present variability of data, include quantitative statistical analyses that compare houses, consider approaches in addition to the cross-validation method used to evaluate the model, and more comprehensively describe data completeness, representativeness, and limitations.

Section 1 should describe the importance of pursuing a long-term goal of producing process-based models and refer to the National Research Council (NRC, 2003) recommendations on this topic. This section should also note that the ~~development of the current~~ developed models ~~is~~are considered ~~a~~ short-term ~~tool~~tools with limited application for estimating emissions.

The limitations of the data set and the various data measurement problems that occurred as part of the NAEMS data collection efforts should be more comprehensively described and summarized in Section 1. For example, data from poultry sites were collected for typical bird grow-out periods, but there are birds (~~e.g., Cornish hens~~) that are grown for much shorter periods (~~e.g., Cornish hens~~) and those (~~e.g., large roasters~~) that are grown for much longer periods- (~~e.g., large roasters~~). These limitations should be

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1 clearly stated because the current EEMs for ammonia would not fit some of the situations well at all
2 (i.e., emissions would be estimated to go to zero for some of the largest birds and would be negative for
3 some of the smallest birds). The discussion on mechanisms of data collection, ventilation rates within
4 barns, and feed nutrients consumed should also be enhanced.

5
6 The introduction section should also clearly acknowledge that the broiler data were collected at an
7 extremely limited number of study sites (four broiler barns on three farms), ~~including two farms at the~~
8 ~~KY site~~. EPA should consider clarifying the text to note that the 2,600 industrial participants in the
9 Consent Agreement are a very small fraction of the one-half million AFOs in the country. EPA should
10 also consider clarifying what percentage of total confinement animal production that these industrial
11 participants represent.

12
13 The text in this section, or in Section 2, would be strengthened by referral to the mechanistic processes
14 ~~behind the drive the emissions that the developed~~ EEMs ~~that EPA employed are estimating~~. This
15 section should describe the primary physical/biological/-chemical mechanisms that lead to emissions of
16 each regulated parameter in relation to the surrogate statistical parameter to strengthen the validity of the
17 statistical model that was employed. For example, the product of bird number and mass is considered a
18 surrogate for fresh manure production that impacts ammonia emissions.

19
20 The text should note that EPA planned to measure several key parameters that would affect emissions
21 generation, such as animal activity ~~(perhaps assessed through lighting program hours for light and dark~~
22 ~~periods)~~, diets, feed rate and composition, water management, ~~and~~ manure composition (moisture and
23 nitrogen), ~~feed composition including total nitrogen that result in releases of gaseous pollutants~~, total
24 number of animals, and ventilation rate. The text should note that EPA did not utilize these parameters
25 during EEM development because EPA judged that data for these variables were insufficient in quantity
26 and/or quality. EPA should describe data that ~~had been~~ was collected but not yet transmitted to EPA as
27 of the development of the EEMs.

28
29 The accurate determination of ventilation rate (VR) is a very important aspect of the NAEMS data
30 collection and is necessary to achieve representative emission data. The determination of accurate
31 ventilation rate should be given more prominence in the report with a concise description of how this
32 was achieved. The description of ventilation systems and control operations for each barn also should
33 be clarified, particularly regarding inlet description and function.

34
35 EPA should also clarify the range of conditions under which the NAEMS-based EEMs can be used. For
36 example, EPA should describe the ambient temperature range during grow-out or litter management
37 period between flocks within which the EEMs can be applied. EPA should also add cautionary notes
38 regarding the use of EEMs outside of the studied range.

39
40 The report should note that that broiler houses are commonly managed as both bird production facilities
41 and as dry manure storage if litter is not completely cleaned out between flocks. It should also discuss
42 the importance of stockpiled litter storage emission measurements (litter being the combination of
43 bedding and manure) and the link of such emissions to the process-based model development. The
44 microbial degradation and natural chemical interactions associated with all the parameters measured
45 should be described. Throughout the report, the emissions from populated houses during grow-out and

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1 empty houses during litter management should be presented separately since the house is managed very
2 differently during these two time periods. In addition, the differential in emissions observed from fully
3 cleaned out houses versus de-caked, built-up litter houses should be presented separately.

4
5 EPA should improve the clarity of the discussions on the NAEMS monitoring sites and on the data
6 available for EEM development. EPA should discuss why the data sets that were used can be
7 considered representative of the industry and the literature. For example, it is unclear how well house
8 CA1B, built in the 1960s, represents modern industry practices. Also, pancake brooders (used in KY)
9 are primarily used by one integrator **so emissions from houses employing such equipment during the**
10 **brooding period are not likely to represent emissions from facilities operated by other integrators.** EPA
11 should develop criteria for considering additional data and how to use such data.

12
13 EPA describes many parameters that were not used in its analysis. EPA should clarify which parameters
14 were used for developing EEMs and discuss the reasons for, and the importance of, not including in the
15 analysis certain parameters for which data were collected **in its analysis.**

16
17 EPA should provide the following additional information regarding the data used in developing EEMs:

- 18 • Identify the number of samples ~~that~~ collected ~~at~~during each sampling event and the periods that
19 data were collected.
- 20 • Clarify the VOC discussions regarding Kentucky and California VOC analyses. This discussion
21 is poorly written and very confusing. EPA should note that the California VOC data were not
22 used and why these data were not used.
- 23 • Describe fan calibration procedures and frequency.
- 24 • Clarify how the change in purge time for first 4 months of gas sampling in CA was addressed.
- 25 • Describe ~~PM~~the sampling schedule for PM10, PM2.5 and TSP samples.
- 26 • Explain what data were to be collected in the sampling plan **and why data that were specified in**
27 **the sampling plan were not collected.**
- 28 • Describe ~~sampler~~ inlet systems used for measurement, and **address** associated issues ~~with use of~~
29 **these inlets in some applications (e.g., aspiration of PM by low volume inlets).**
- 30 • Describe ventilation rate which includes discussion on the FANS system and repeated
31 calibrations.

- 32
33 • **The KY1B data-set is available at <http://www.epa.gov/airquality/agmonitoring/data.html>. The**
34 **report does not indicate that ambient weather data and confinement data are available for the**
35 **Kentucky site, although the data posted on the website spreadsheet is described as containing**
36 **“daily mean concentrations of pollutants, weather and barn conditions.” The report should**
37 **clarify this potential discrepancy.**

38 EPA should clearly specify criteria for data completeness, how data can be used, eliminating data, how
39 background concentration data were collected, and use of data available in the literature for a modeling
40 verification effort. EPA should also discuss why a 75% completeness value was used as a threshold for
41 using data, why there are missing data days, and why some data were collected in some seasons and not
42 in others. EPA should also clarify how EPA identified outliers in the data and the reasons for their
43 inclusion or omission. The discussion on seasonal influences should be improved to discuss whether

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1 such influences should be incorporated into the model. The text should also describe how anomalies are
2 defined and applied in the data set.

4 **4.2 Draft EPA Lagoon Report**

6 SAB recommends that EPA reorganize the report and rewrite several sections to address various
7 concerns of the SAB. Various recommendations are provided to more comprehensively describe data
8 completeness, representativeness, and limitations. In addition, many comments that SAB provides to
9 the Broiler Report also apply to the Lagoon Report (e.g., comments on data completeness, use of data,
10 and statistical and process-based model approaches). EPA should review the Lagoon report and
11 incorporate such comments as appropriate.

13 Section 1 should describe the importance of pursuing a long-term goal for developing process-based
14 models, and refer to the NRC (2003) recommendations on this topic. This section should also note that
15 the development of empirical models is considered a short-term tool for estimating emissions.

17 The discussion on the U.S. dairy and swine industries should be rewritten-. This section notes that due
18 to the limited amount of nitrogen content, solid content and pH of the lagoon liquid, these data were not
19 included in the EEM. Section 2 also notes that data on manure residence time, amount of sulfur ingested
20 by an animal, and amount of carbon in feed were not collected. The limitations of the data set and the
21 various data measurement problems that occurred as part of the NAEMS data collection efforts should
22 be summarized.

24 The discussion on manure management, storage and stabilization should be revised. EPA's discussion
25 on the design difference between storage and treatment ponds (i.e., basins and lagoons, respectively) is
26 inconsistent and incorrect; treatment ponds are designed specifically for biological treatment, and
27 storage ponds are not designed for biological treatment. In addition, waste characteristics for swine and
28 dairy animals are significantly different. Standardized definitions exist for manure treatment/storage
29 structures; EPA and the NAEMS scientists should use ASAE Standard: Uniform Terminology for Rural
30 Waste Management (ASABE S292.5). The text should describe the processes that generate ammonia
31 from nitrogen and that cause volatilization of that nitrogen. The text should also describe the microbial
32 degradation and natural chemical interactions for all parameters measured.

34 The report should be rewritten to include additional details on the dairy and swine industry, in particular
35 the waste handling techniques and manure characteristics. Additional details on hydrocarbon and VOC
36 sampling results, average dairy cow weight, and manure management systems should be provided.
37 Additional information on the lagoons where data were collected should be provided, as well as
38 information on what constitutes a standard lagoon throughout the industry. In addition, it should be
39 noted that EPA's analysis used data from a wash water dairy lagoon, not a manure storage lagoon,
40 which may affect the EEM estimation efforts.

42 EPA should specify reasons for selecting criteria for data completeness, how data can be used, criteria
43 for eliminating data, how background data were collected, and use of data available in the literature for a
44 modeling verification effort. EPA should also clarify how outliers were identified and the reasons for
45 their inclusion or omission.

Suggested Changes to 9/28/12 Draft Report, for review and deliberations by the SAB Animal Feeding Operations Emissions Panel during the 10/24/12 teleconference call –

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4.3 References for Broiler and Lagoon Reports:

SAB suggests that EPA consider the following additional references to improve the literature base for the draft EPA Reports and help ensure a more comprehensive understanding of AFO broiler and/or swine and dairy lagoon/basin operations:

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Suggested Changes to 9/28/12 Draft Report, for review and deliberations by the SAB Animal Feeding Operations Emissions Panel during the 10/24/12 teleconference call –

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5 | **Appendices:**
6 |

7 | The Appendices reference several pre-study validation studies. The results from these validation studies
8 | should be included in the Report so that it is possible to evaluate the data quality that may have been
9 | generated using these tested techniques.

1
2 | **APPENDIX A — EPA’S CHARGE QUESTIONS**
3
4

5 February 17, 2012
6

7 **MEMORANDUM**
8

9 **SUBJECT:** Animal Feeding Operations Air Emissions Estimating
10 Methodologies from the National Air Emissions Monitoring Study
11

12 **FROM:** Stephen D. Page, Director
13 Office of Air Quality Planning and Standards (C404-04)
14

15 **TO:** Ed Hanlon
16 Designated Federal Officer
17 Animal Feeding Operations Emission Review Panel
18 EPA Science Advisory Board Staff Office (1400R)
19

20 This memorandum requests that the Science Advisory Board (SAB) review and comment on the draft
21 emissions estimating methodologies (EEMs) for animal feeding operations (AFOs). In preparation for
22 this review, the SAB has formed the *Animal Feeding Operations Emission Review Panel*. We envision
23 conducting multiple meetings of this panel to cover the material we are requesting to be reviewed. This
24 memorandum contains background material and charge questions for review by the expert SAB Panel at
25 the initial meeting. We request that these materials be forwarded to the SAB Panel for their review.
26

27 As the attachment and associated documents illustrate, the EPA staff has carefully considered the data
28 collected as part of the National Air Emissions Monitoring Study (NAEMS) and now ask the Panel to
29 refine and comment upon our work thus far to create EEMs. To bound and define the discussion, the
30 attachment offers charge questions for the Panel to consider.
31

32 By way of background, in 2005, the EPA entered a voluntary consent agreement with the AFO industry
33 in which AFOs that chose to sign the Air Compliance Agreement (Agreement) shared responsibility for
34 funding a nationwide emissions monitoring study. The NAEMS monitoring protocol was developed
35 through a collaborative effort of AFO industry experts, university scientists, U.S. Department of
36 Agriculture and EPA scientists and other stakeholders. The monitoring study was designed to gather
37 data for developing methodologies for estimating emissions from AFOs and to help AFOs determine
38 and comply with their regulatory responsibilities under the Clean Air Act (CAA), the Comprehensive
39 Environmental Response, Compensation and Liability Act (CERCLA), and the Emergency Planning and
40 Community Right-To-Know Act (EPCRA). Once the EPA publishes the applicable EEMs, the
41 Agreement requires each participating AFO to certify that it is in compliance with all relevant
42 requirements of the CAA, CERCLA and EPCRA.
43

44 We appreciate your efforts and those of the Panel to prepare for the upcoming meeting and look forward
45 to discussing this project in detail. Questions regarding the attached materials should be directed to Ms.

Suggested Changes to 9/28/12 Draft Report, for review and deliberations by the SAB Animal Feeding Operations Emissions Panel during the 10/24/12 teleconference call –

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1 Robin Dunkins, EPA-OAQPS (telephone: 919-541-5335; email: dunkins.rob@epa.gov).

2

3 Attachment

4

5 cc: Bill Harnett

6 Robin Dunkins

7 Larry Elmore

8 Lawrence Elworth

9 Allison Mayer

10 Janet McCabe

11 Peter Tsirigotis

12 |

13

14

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4 **ATTACHMENT**

5
6 **Regulatory Background**

7 In 2005, the EPA entered a voluntary consent agreement with the animal feeding operations (AFO)
8 industry in which AFOs that chose to sign the Air Compliance Agreement (Agreement) shared
9 responsibility for funding the National Air Emissions Monitoring Study (NAEMS). Approximately
10 2,600 AFOs, representing nearly 14,000 facilities that include broiler, dairy, egg layer and swine
11 operations, received the EPA’s approval to participate in the Agreement.

12 To provide a framework for the NAEMS, AFO industry experts, university and government scientists
13 and other stakeholders collaborated to develop a comprehensive monitoring plan. The study was
14 designed to generate scientifically credible data to characterize emissions from the participating animal
15 sectors.

16
17 Consistent with the Agreement, the Agriculture Air Research Council (AARC), a nonprofit entity
18 comprised of participating AFO industry representatives, administered the monitoring study. The
19 AARC was responsible for selecting the Independent Monitoring Contractor (IMC) and the study’s
20 Science Advisor with EPA approval. The Agreement outlined the roles and responsibilities of the
21 AARC, the IMC and the Science Advisor.

22
23 The monitoring plan specified the general geographic location of the farms to be monitored, animal
24 production phase, ventilation type, manure management/handling system and other pertinent
25 information for each animal sector.

- 26 • For broilers, two sites were to be monitored - one on the West Coast and the other in the
27 Southeast. Both were to be mechanically ventilated and have litter on the floor.
- 28 • For the swine industry, the sites were to be located in the Southeast (sow and finisher), Midwest
29 (sow and finisher), and West (sow). Mechanically-ventilated buildings, a deep pit building,
30 lagoons and basin manure storage types were to be monitored.
- 31 • For dairy, both naturally- and mechanically-ventilated buildings, lagoons and basins were
32 monitored. Five dairies were monitored, one dairy in each of the following geographical areas:
33 Northeast, Midwest, Northwest, West and South.

34
35 For confinement sources, the IMC monitored for ammonia (NH₃), particulate matter (PM₁₀, PM_{2.5}, TSP),
36 volatile organic compounds (VOCs) and hydrogen sulfide (H₂S). For lagoons and basins, H₂S, NH₃ and
37 VOC were to be monitored. Accordingly, the EPA is then responsible for developing EEMs for each of
38 these pollutants.

39
40 **Charge to the Science Advisory Board (SAB) AFO Air Emissions Review Panel**

41
42 In preparation for the first and second meeting, the EPA has analyzed the NAEMS data for two broiler
43 sites and nine swine and dairy lagoons/basins. For the purpose of this study, the EPA used the
44 description of a lagoon and basin as provided in the MidWest Plan Service “Manure Storages” (MWPS-
45 18 Section 2) document. According to MWPS, “A lagoon is a biological treatment system designed and

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1 operated for biodegradation of organic matter in animal manure to a more stable end product. A basin,
2 while similar to but smaller than a lagoon, is designed to store manure only and is not a treatment
3 system.”
4

5 For a broiler confinement house, the EPA has developed draft EEMs for NH₃, PM₁₀, PM_{2.5}, TSP, VOC
6 and H₂S. For swine and dairy lagoons/basins, the EPA has only developed a draft EEM for NH₃. The
7 documents provided to the SAB describe the sites monitored; the data submitted to the EPA; and a
8 detailed discussion of the statistical methodology used to develop the draft EEMs. This material is
9 provided to inform the SAB panel of the EEM development process used by the agency. In subsequent
10 meetings, the EPA will address draft EEMs for egg-layers, swine and dairy confinement houses and
11 other pollutants for swine and dairy lagoons/basins.
12

13 **Issue 1: Statistical Methodology used to develop draft EEMs**

14
15 The EPA seeks the SAB’s input on the statistical methodology used by the EPA to develop the draft
16 EEMs. Section 7.0 and 8.0 of the broiler document and section 5.0 of the swine and dairy lagoon/basin
17 document provide an overview of the statistical methodology used to develop the draft EEMs. A flow
18 diagram of the statistical methodology is provided in Figure 7-1 in the broiler document and Figure 5-1
19 in the swine and dairy lagoon/basin document. The EPA considers this statistical methodology to be the
20 best approach for analyzing the data and intends to use this same approach to develop draft EEMs for
21 the egg-layers, swine and dairy confinement houses.
22

23 Using the process described in the sections listed above, we developed a mean trend function that
24 provides a point prediction of emissions under a given set of conditions. We chose an appropriate mean
25 trend function to quantify the relationship between predictor variables and pollutant emissions by
26 analyzing the emissions data and incorporating knowledge of the emissions generating processes. The
27 EEM development process also involves choosing a probability distribution and covariance function to
28 appropriately quantify other contributions to variability in emissions, and thereby to accurately quantify
29 methods at all stages. If necessary, we will adjust the statistical methodology based on our review of the
30 SAB’s input.
31

32 **Question 1:** Please comment on the statistical approach used by the EPA for developing the draft EEMs
33 for broiler confinement houses and swine and dairy lagoons/basins. In addition, please comment on
34 using this approach for developing draft EEMs for egg-layers, swine and dairy confinement houses.
35

36 **Issue 2: Statistical Methodology used to develop swine and dairy lagoon/basin draft EEMs**

37
38 After conducting an initial analysis of the NAEMS data submitted for swine and dairy lagoons/basins,
39 the EPA decided to focus on developing a draft EEM for NH₃. The EPA’s review of current literature
40 indicates that lagoon/basin emissions are influenced by several factors, one of these being lagoon/basin
41 temperature. To ensure that the dataset used to develop the draft EEM represented all seasonal
42 meteorological conditions for the entire two year monitoring period, the EPA decided to combine the
43 swine and dairy data. Combining the swine and dairy lagoon/basin dataset also resulted in combining
44 lagoon and basin emissions data.
45

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1 To maximize the number of NH₃ emissions measurements used to develop the draft EEM, the EPA used
2 static predictor variables (SPVs) as surrogates for data on lagoon/basin conditions (i.e., nitrogen content
3 of lagoon liquid, lagoon pH, oxidation reduction potential and temperature). The static variables of
4 animal type, total live mass of animal capacity on the farm and the surface area of the lagoon were used
5 to represent NH₃ precursor loading and the potential for release to the air. Consistent with operating
6 parameters associated with statistical degrees-of-freedom, we concluded that two degrees of freedom
7 was the maximum that the data would credibly allow for inclusion in the developing the draft EEM. As
8 a result, the EPA developed three sets of draft EEMs, using the paired combinations of these static
9 variables (i.e., animal type, surface area, farm size) and the continuous variables representing
10 meteorological conditions (i.e., temperature, atmospheric pressure, humidity, wind speed, solar
11 radiation).

12
13 **Question 2:** Please comment on the agency's decision to combine the swine and dairy dataset to ensure
14 that all seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's
15 comments on whether the agency should combine lagoon and basin data.

16
17 **Question 3:** Please comment on the agency's decision to use ~~static predictor variables~~ SPVs as
18 surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB
19 recommend that EPA consider specific alternative approaches for statistically analyzing the data that
20 would allow for the site-specific lagoon liquid characteristics to be used as predictor variables?

21
22 **Question 4:** Does the SAB recommend that EPA consider alternative approaches for developing the
23 draft NH₃ EEM that balances the competing needs for a large dataset (to reflect seasonal meteorological
24 conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions. If
25 so, what specific alternative approaches would be appropriate to consider?

26 27 **Issue 3: Negative and Zero Data**

28
29 Some emissions measurements were reported to the EPA as either negative or zero emissions values.
30 When developing the draft EEMs, the EPA used the following general approach regarding inclusion of
31 negative and zero emissions values in the data.

- 32
33 • The EPA evaluated whether the negative or zero values represent the variability in emissions
34 measurements due to the means of obtaining the measurements. For example, negative values
35 for a pollutant concentration might result when the concentration of the pollutant falls below the
36 minimum detection limit of a monitor. For all EEM datasets, the EPA included zero values
37 because these values potentially represent instances where the emissions from the source were
38 zero (e.g., a frozen lagoon), or the background and pollutant concentrations from the source were
39 the same. Regarding negative values, in cases where the dataset available to develop draft EEMs
40 was relatively large and the emissions were significantly greater than zero, the EPA excluded
41 negative emissions values from the EEM datasets. The EPA used this approach to develop the
42 entire broiler confinement house draft EEMs and swine and dairy lagoon/basin NH₃ draft EEMs.
43
- 44 • The EPA reviewed the data to see if the data quality measures were properly performed
45 according to the Quality Assurance Project Plan.

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- If the EPA identified data where the quality assurance measures were not followed, we contacted the science advisor to determine if the corrected data could be submitted to the EPA.

The EPA has conducted a preliminary analysis of the swine and dairy lagoon/basin H₂S emissions data. Our analysis indicates that we may need to modify our approach for handling negative and zero data in order to develop a draft H₂S EEM for swine and dairy lagoons/basins. A modification may be needed due to the limited number of H₂S emissions values, the presence of a greater percentage of negative emissions values and emissions values that are closer to zero than the NH₃ emissions for swine and dairy lagoons/basins. The EPA’s concern is that failure to include the negative measurements in the dataset, or setting them equal to zero, would result in an EEM that fails to fully quantify uncertainty around the point prediction of emissions attributable to measurement error.

Question 5: Please comment on the EPA’s approach for handling negative or zero emission measurements.

Question 6: In the interest of maximizing the number of available data values for development of the draft H₂S EEMs for swine and dairy lagoons/basins, does SAB recommend any alternative approaches for handling negative and zero data other than the approach used by the agency.

Issue 4: Volatile Organic Compounds (VOC) Data

The EPA reviewed the VOC data submitted for the California and Kentucky broiler sites. The two sites used different VOC measurement techniques. Based on our analysis of the measurement and analytical techniques and the VOC data, the EPA decided to use only the VOC data from the Kentucky sites when developing the draft VOC EEM.

Question 7: Please comment on the approach EPA used to develop the draft broiler VOC EEM.